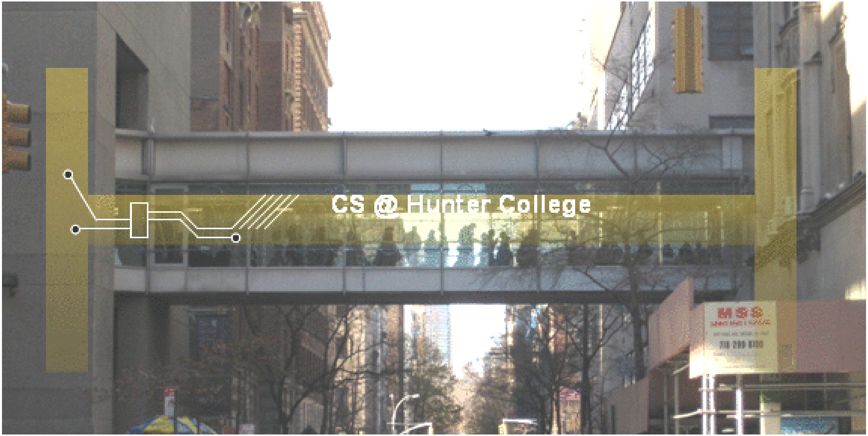
CSci 127: Introduction to Computer Science



hunter.cuny.edu/csci

Announcements

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  Thursday-Saturday, 28-31 November.

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  Thursday-Saturday, 28-31 November.
- In response to wrap-up requests, additional challenges today with while loops and binary & hexadecimal numbers.

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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In Pairs or Triples:

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.')
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Python Tutor

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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.

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

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

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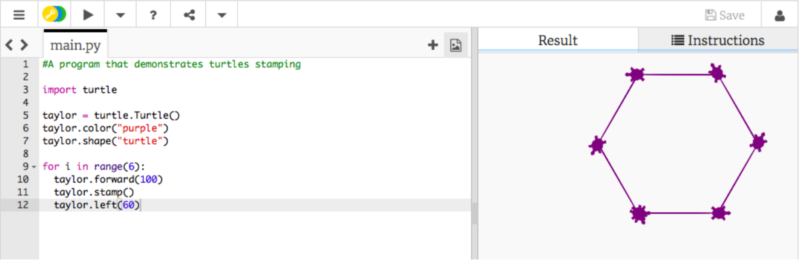
- As well as definite loops & the turtle package:



Week 2: variables, data types, more on loops & range()

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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(x)

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

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

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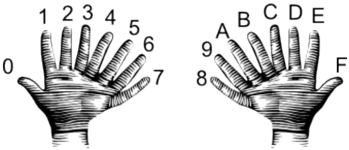
Navy	#000080	
DarkBlue	#00008B	
MediumBlue	#0000CD	
Blue	#0000FF	



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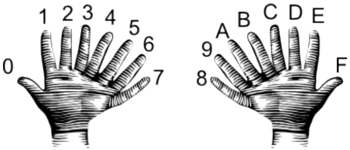

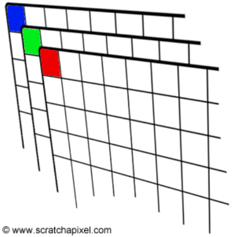

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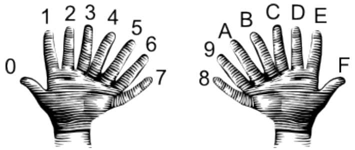

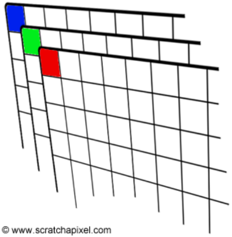

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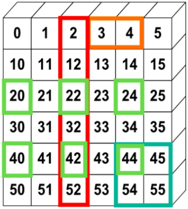
```
>>> a[0,3:5]
array([3,4])

>>> 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]])
```



Week 4: design problem (cropping images) & decisions

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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.
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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

```python
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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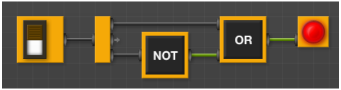
in1		in2	*returns:*
False	and	False	False
False	and	True	False
True	and	False	False
True	and	True	True



Week 6: structured data, pandas, & more design

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All population figures are consistent with present-day boundaries.,,,,,,
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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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import matplotlib.pyplot as plt
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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.plot(x="Year")
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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
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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
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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
```
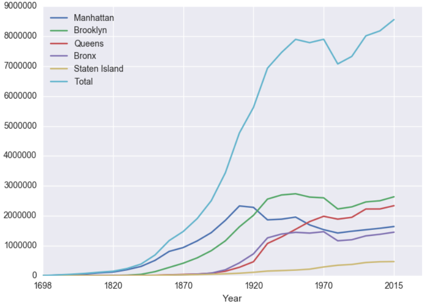

`nycHistPop.csv`

In Lab 6



Week 7: functions

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

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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.')
    dist = int(input('Enter distance: '))

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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.

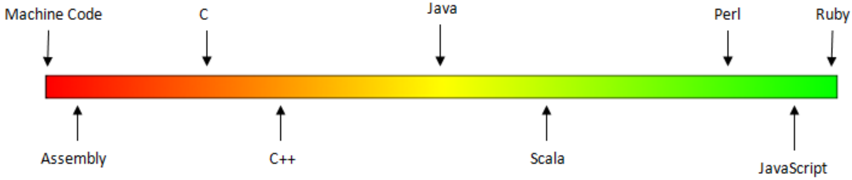
Python & Circuits Review: 10 Weeks in 10 Minutes

- 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

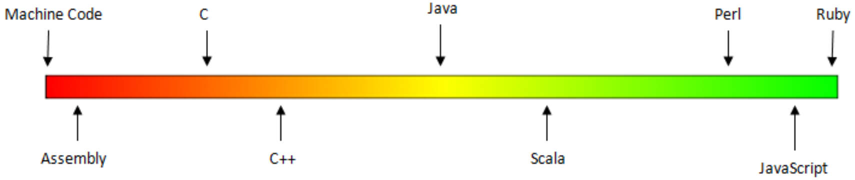
Low-Level vs. High-Level Languages



(codeCommit)

- Can view programming languages on a continuum.

Low-Level vs. High-Level Languages



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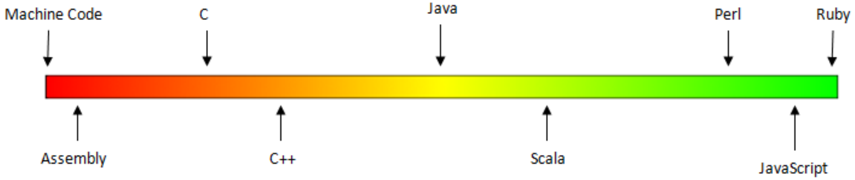

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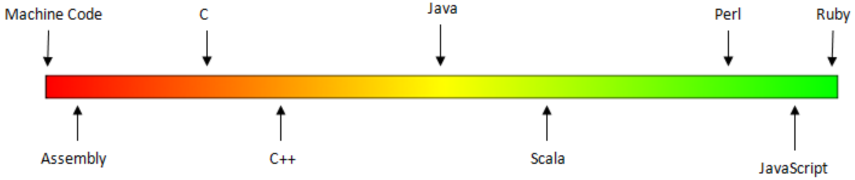

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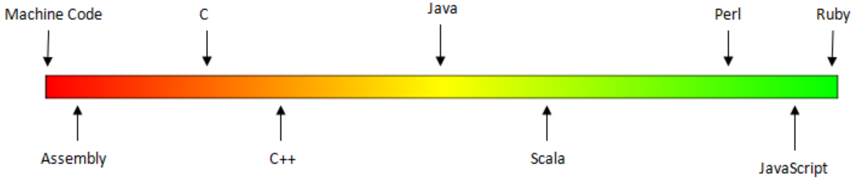

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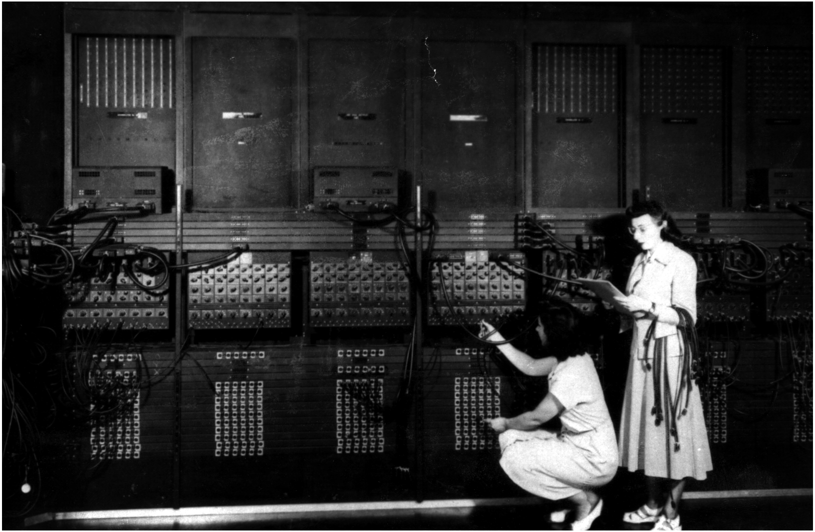
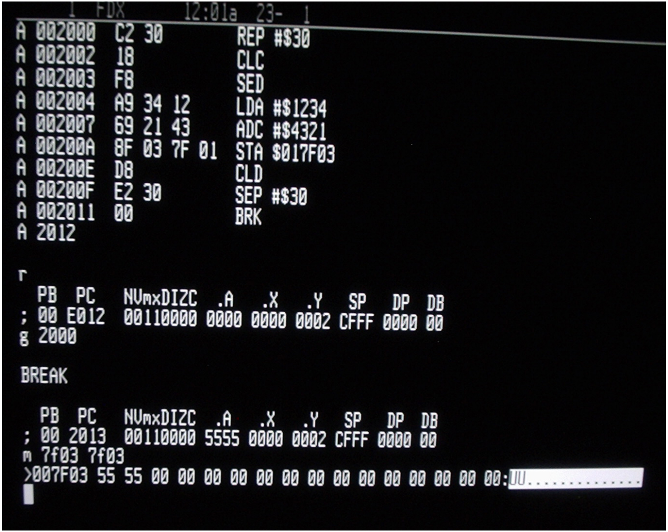
- Some languages, like C, are in between– allowing both low level access and high level data structures.

Machine Language



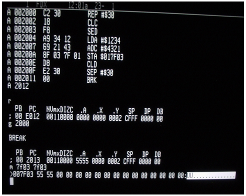
(Ruth Gordon & Ester Gerston programming the ENIAC, UPenn)

Machine Language



(wiki)

Machine Language



(wiki)

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

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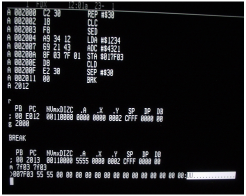

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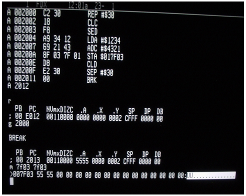

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- Due to its small set of commands, processors can be designed to run those commands very efficiently.

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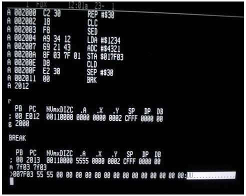

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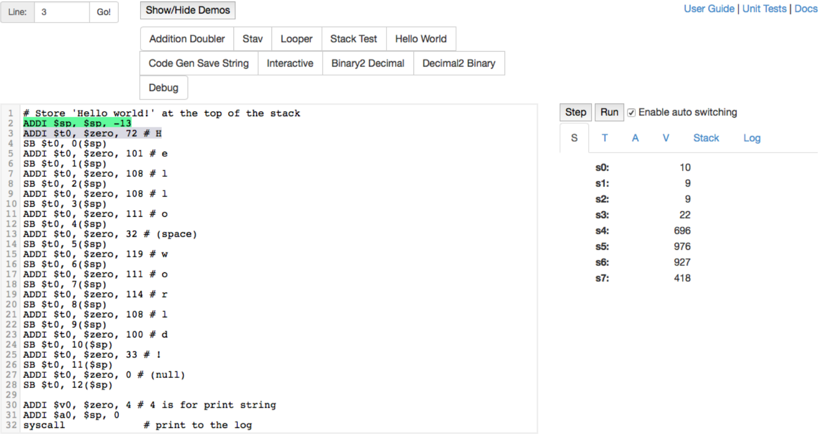
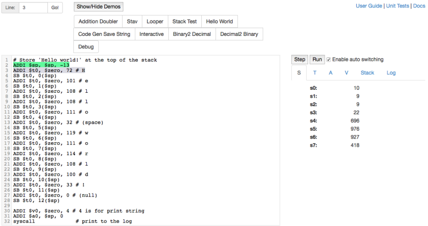
- More in future architecture classes....

“Hello World!” in Simplified Machine Language



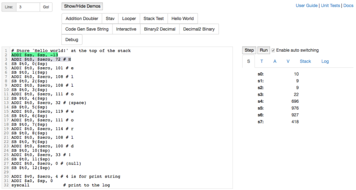
(WeMIPS)

WeMIPS



(Demo with `WeMIPS`)

MIPS Commands



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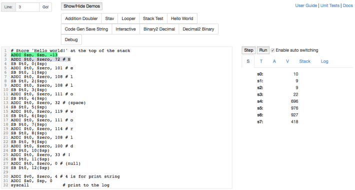
MIPS Commands



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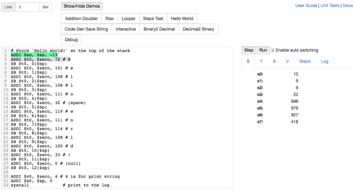

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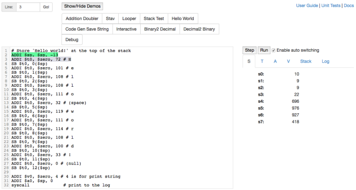

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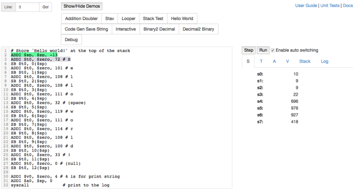

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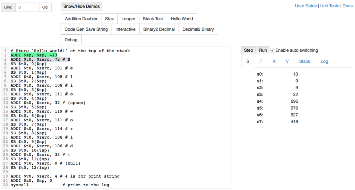

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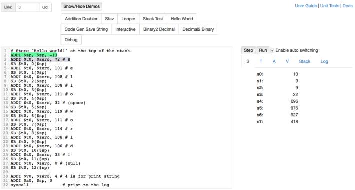

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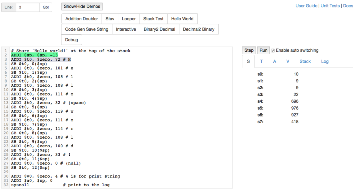

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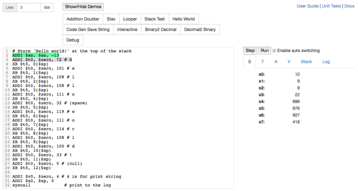
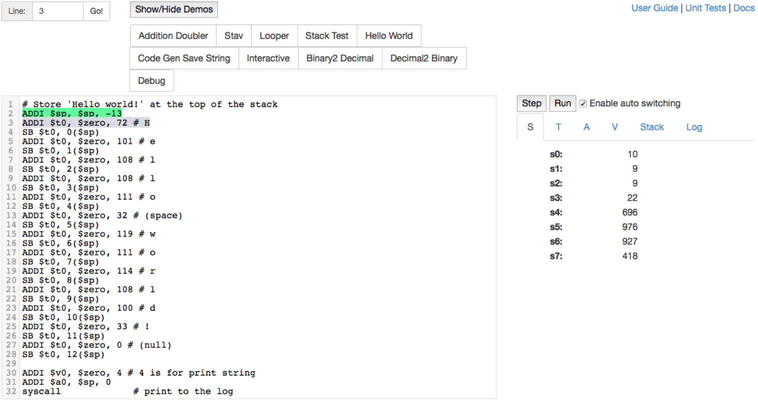
  `j done`

MIPS Commands



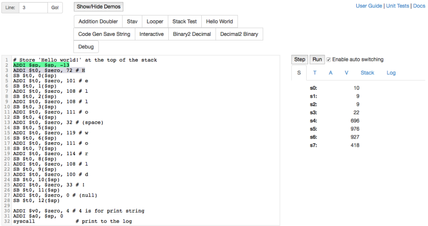
- **Registers:** locations for storing information that can be quickly accessed. Names start with '\$': `$s0`, `$s1`, `$t0`, `$t1`,...
- **R Instructions:** Commands that use data in the registers:
  `add $s1, $s2, $s3` (Basic form: `OP rd, rs, rt`)
- **I Instructions:** instructions that also use intermediate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

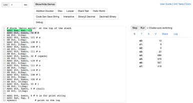


(Demo with `WeMIPS`)

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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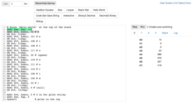
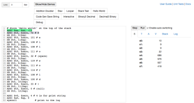


Loops & Jumps in Machine Language



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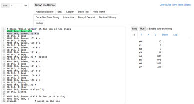

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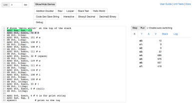

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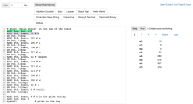

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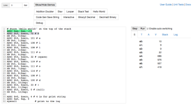
Loops & Jumps in Machine Language



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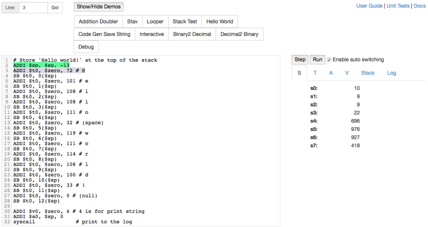
  - See reading for more variations.

Jump Demo



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Today's Topics

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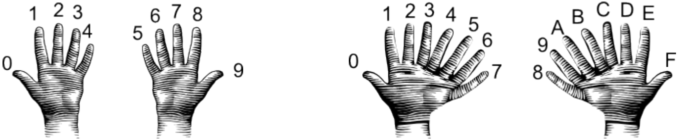
- Machine Language: Jumps & Loops
- **Binary & Hex Arithmetic**
- Final Exam: Format

Hexadecimal to Decimal: Converting Between Bases



(from i-programmer.info)

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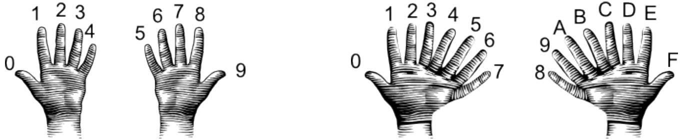

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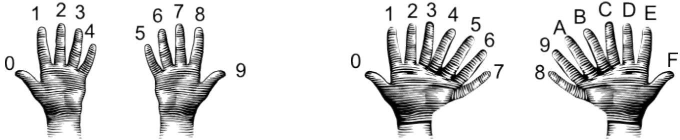

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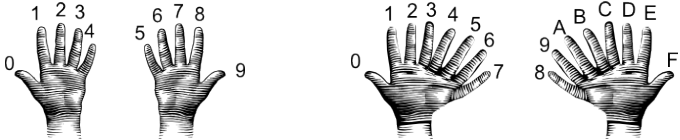

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    `2 in decimal is 2.`

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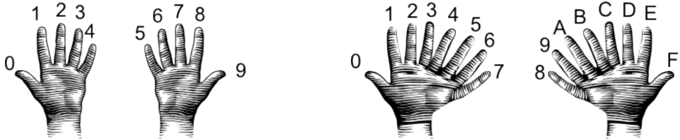

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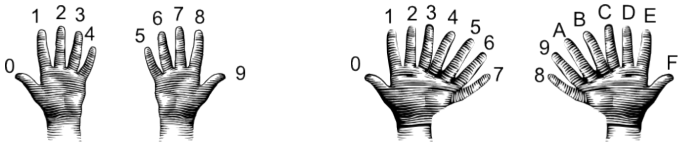

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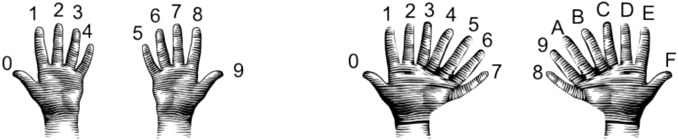

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```
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A in decimal digits is 10.
32 + 10 is 42.
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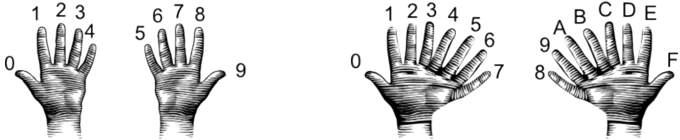

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    Answer is 42.
  - Example: what is 99 as a decimal number?

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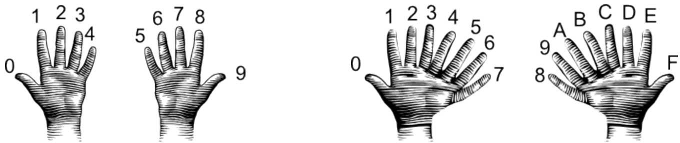

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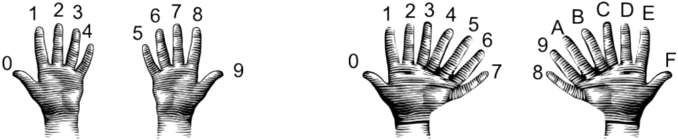

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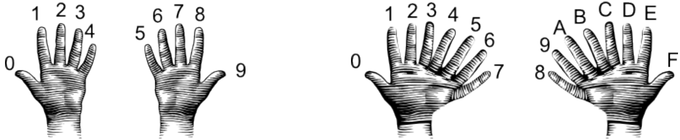

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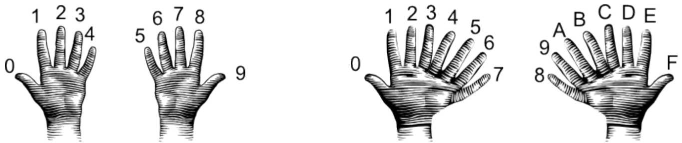

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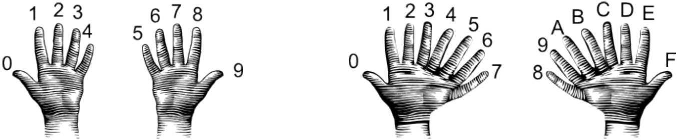

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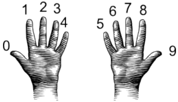

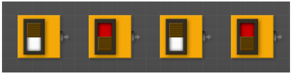

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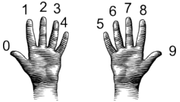

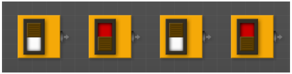

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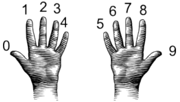

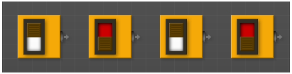

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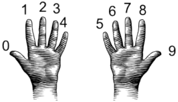

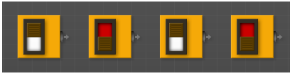

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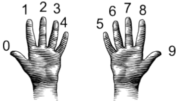

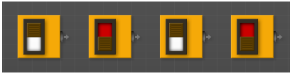

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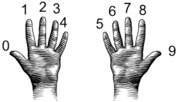

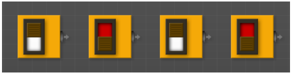

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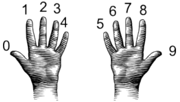

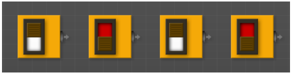

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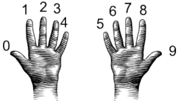

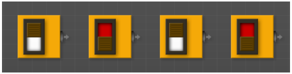

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  - Divide remainder by 2 ($= 2^1$). Quotient is the next digit.
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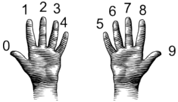
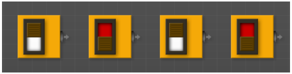
Decimal to Binary: Converting Between Bases





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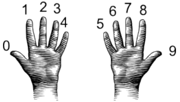
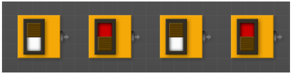
  - Divide remainder by 2 ($= 2^1$). Quotient is the next digit.
  - The last remainder is the last digit.
  - Example: what is 130 in binary notation?

Decimal to Binary: Converting Between Bases





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    `130/128 is 1 rem 2.`

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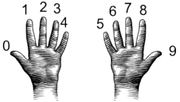

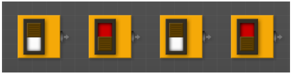

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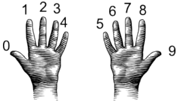

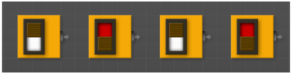

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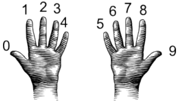

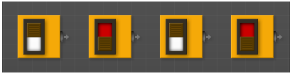

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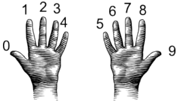

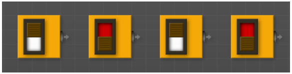

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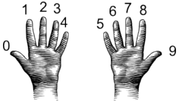

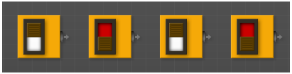

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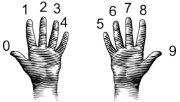

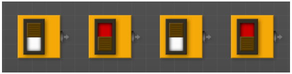

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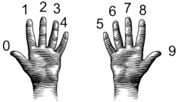

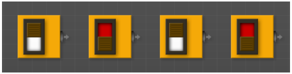

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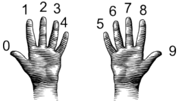

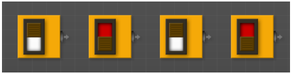

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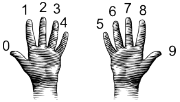

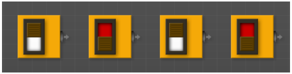

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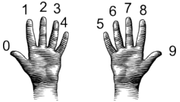

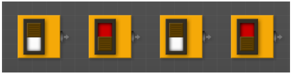

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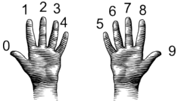

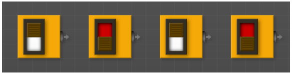

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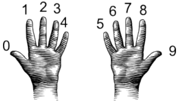

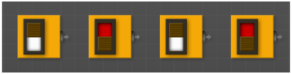

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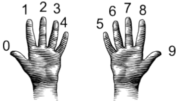

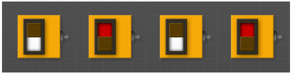

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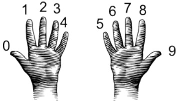

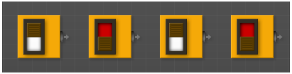

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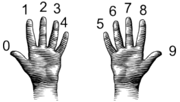

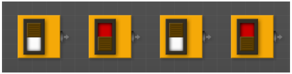

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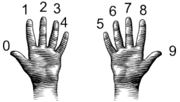

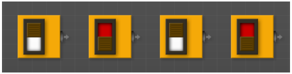

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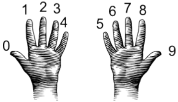
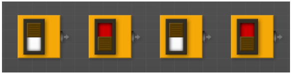
```

Decimal to Binary: Converting Between Bases





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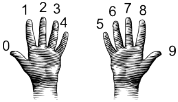

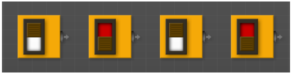

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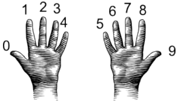

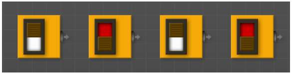

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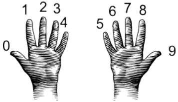
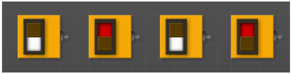
```

Decimal to Binary: Converting Between Bases





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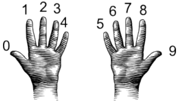
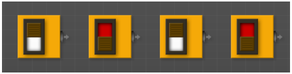
Adding the last remainder:               10000010
```

Decimal to Binary: Converting Between Bases





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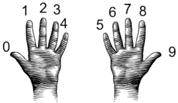
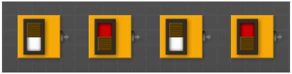
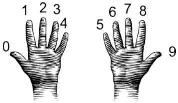
Decimal to Binary: Converting Between Bases

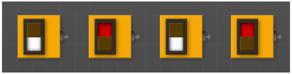




- Example: what is 99 in binary notation?

Decimal to Binary: Converting Between Bases

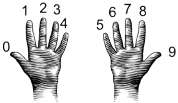


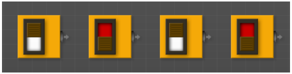


- Example: what is 99 in binary notation?

  `99/128 is 0 rem 99.`

Decimal to Binary: Converting Between Bases





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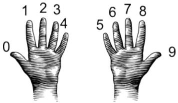
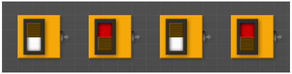
  `99/128 is 0 rem 99. First digit is 0:`

Decimal to Binary: Converting Between Bases

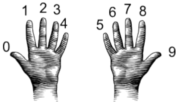


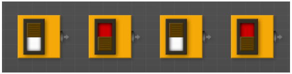


- Example: what is 99 in binary notation?

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

Decimal to Binary: Converting Between Bases





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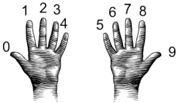

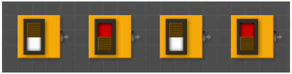

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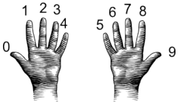

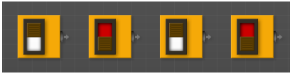

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99/128 is 0 rem 99. First digit is 0:    0...
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35/32 is 1 rem 3.
```

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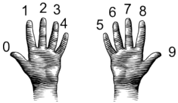

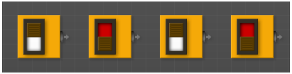

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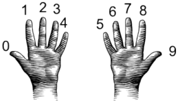

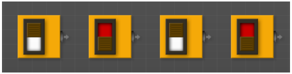

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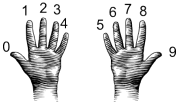

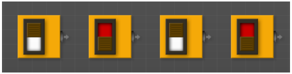

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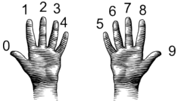

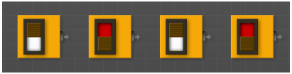

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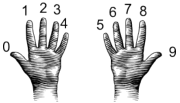

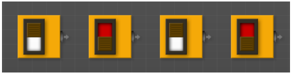

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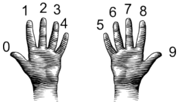

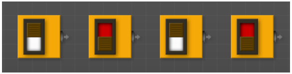

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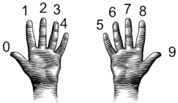

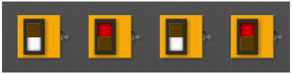

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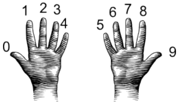

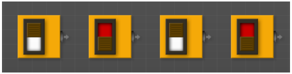

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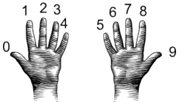

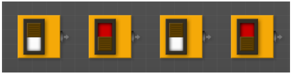

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3/4 is 0 remainder 3.
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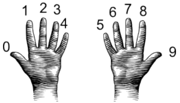

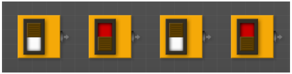

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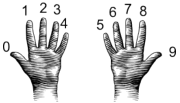

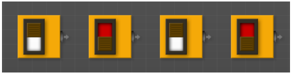

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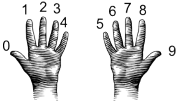
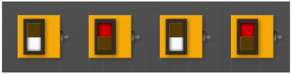
  `35/32 is 1 rem 3. Next digit is 1:` 011...
  `3/16 is 0 rem 3. Next digit is 0:` 0110...
  `3/8 is 0 rem 3. Next digit is 0:` 01100...
  `3/4 is 0 remainder 3. Next digit is 0:` 011000...

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.`	

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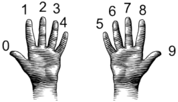

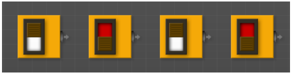

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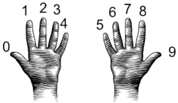

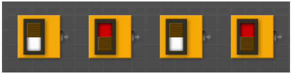

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3/4 is 0 remainder 3. Next digit is 0:     011000...
3/2 is 1 rem 1. Next digit is 1:           0110001...
```

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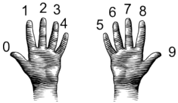

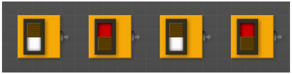

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`Adding the last remainder:`	01100011

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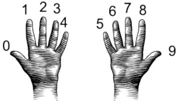

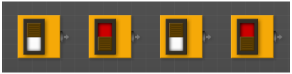

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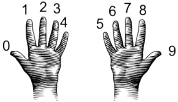
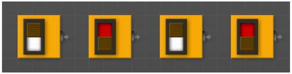
`Adding the last remainder:`	01100011

Answer is 1100011.

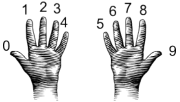
Binary to Decimal: Converting Between Bases

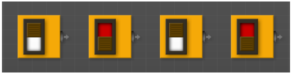




- From binary to decimal:
  - Set sum = last digit.

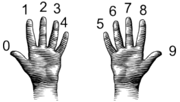
Binary to Decimal: Converting Between Bases

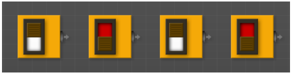




- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.

Binary to Decimal: Converting Between Bases





- From binary to decimal:
  - Set sum = last digit.
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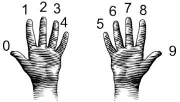
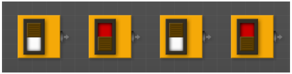
Binary to Decimal: Converting Between Bases





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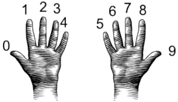
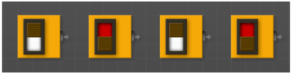
Binary to Decimal: Converting Between Bases





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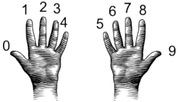

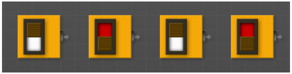

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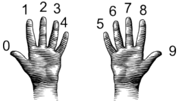
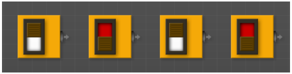
Binary to Decimal: Converting Between Bases





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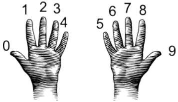
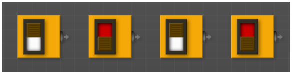
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.

Binary to Decimal: Converting Between Bases





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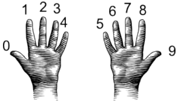
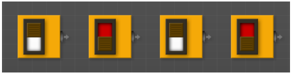
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.

Binary to Decimal: Converting Between Bases





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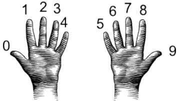

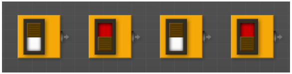

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  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

    `Sum starts with:`

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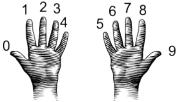

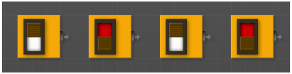

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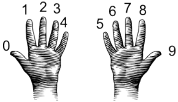
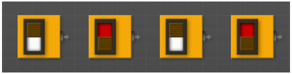
  - Example: What is 111101 in decimal?

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

Binary to Decimal: Converting Between Bases





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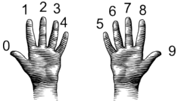

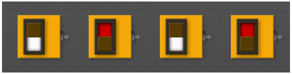

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1*4 = 4.  Add 4 to sum:
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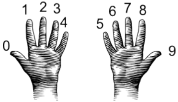
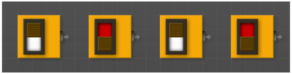
Binary to Decimal: Converting Between Bases





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  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

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

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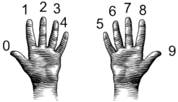

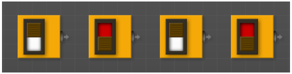

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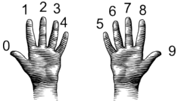
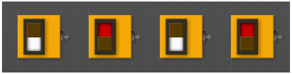
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
Sum starts with:            1
0*2 = 0.  Add 0 to sum:     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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  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

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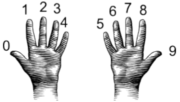
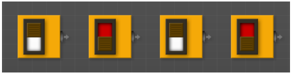
1*4 = 4.  Add 4 to sum:   5
1*8 = 8.  Add 8 to sum:   13
```

Binary to Decimal: Converting Between Bases





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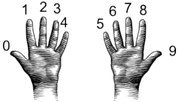
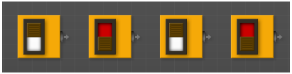
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
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

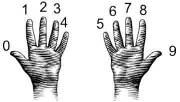


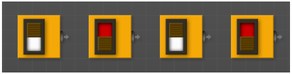


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.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

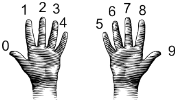


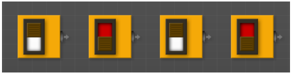


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.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

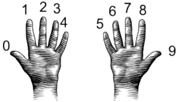


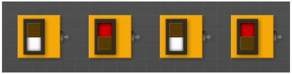


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.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

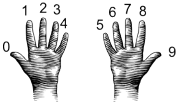


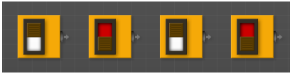


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.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

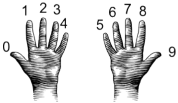


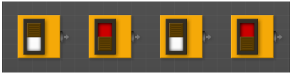


- Example: What is 10100100 in decimal?

  `Sum starts with:`

Binary to Decimal: Converting Between Bases

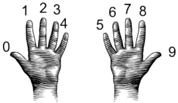


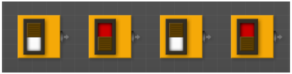


- Example: What is 10100100 in decimal?

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

Binary to Decimal: Converting Between Bases

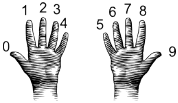


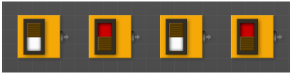


- Example: What is 10100100 in decimal?

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

Binary to Decimal: Converting Between Bases

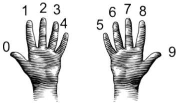


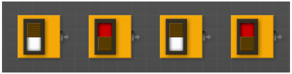


- Example: What is 10100100 in decimal?

```
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

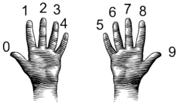


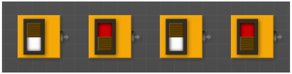


- Example: What is 10100100 in decimal?

```
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

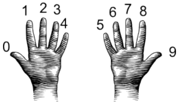


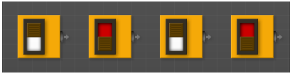


- Example: What is 10100100 in decimal?

```
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

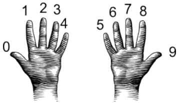


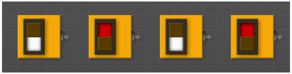


- Example: What is 10100100 in decimal?

```
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

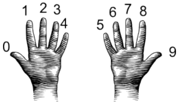


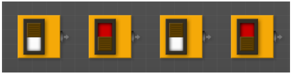


- Example: What is 10100100 in decimal?

```
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

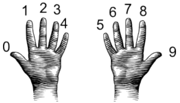


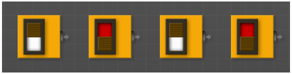


- Example: What is 10100100 in decimal?

```
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

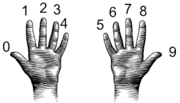


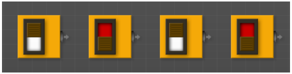


- Example: What is 10100100 in decimal?

```
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

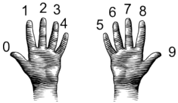


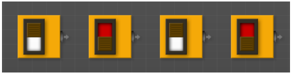


- Example: What is 10100100 in decimal?

```
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

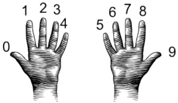


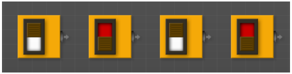


- Example: What is 10100100 in decimal?

```
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

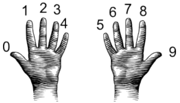


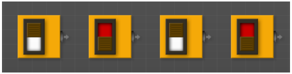


- Example: What is 10100100 in decimal?

```
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

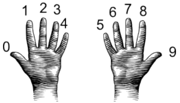


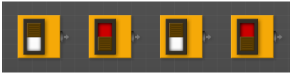


- Example: What is 10100100 in decimal?

```
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

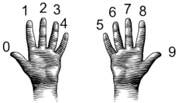


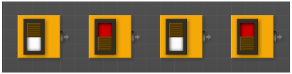


- Example: What is 10100100 in decimal?

```
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



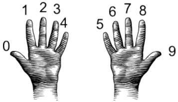


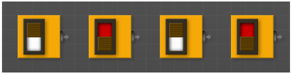
- Example: What is 10100100 in decimal?

```
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.

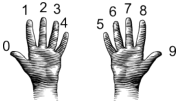
Design Challenge: Incrementers

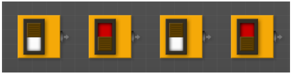




- Simplest arithmetic: add one ("increment") a variable.

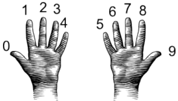
Design Challenge: Incrementers

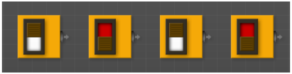




- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

Design Challenge: Incrementers

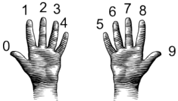


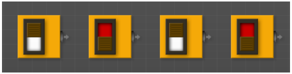


- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

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

Design Challenge: Incrementers



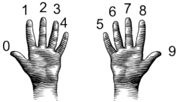


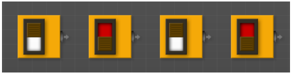
- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

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

- Challenge: Write an algorithm for incrementing numbers expressed as words.

Design Challenge: Incrementers





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

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def addOne(n):
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- Challenge: Write an algorithm for incrementing numbers expressed as words.
  Example: `"forty one"` → `"forty two"`

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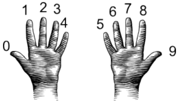

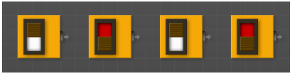

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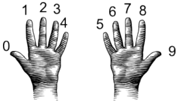

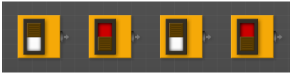

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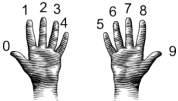

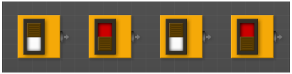

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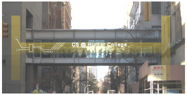
  Example: `"1001"` → `"1010"`

Recap

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



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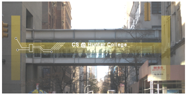

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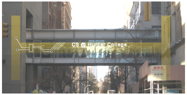

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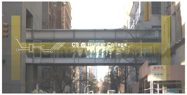

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Today's Topics

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

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

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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- You may not use a computer, calculator, tablet, smart watch, or other electronic device.
- Do not open this exam until instructed to do so.

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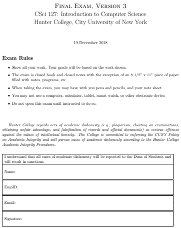

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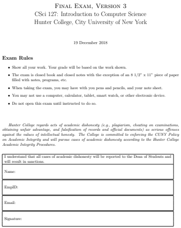
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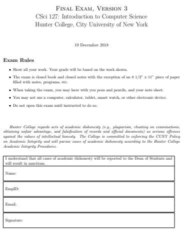
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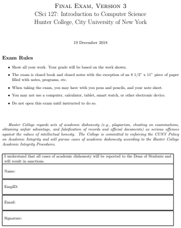
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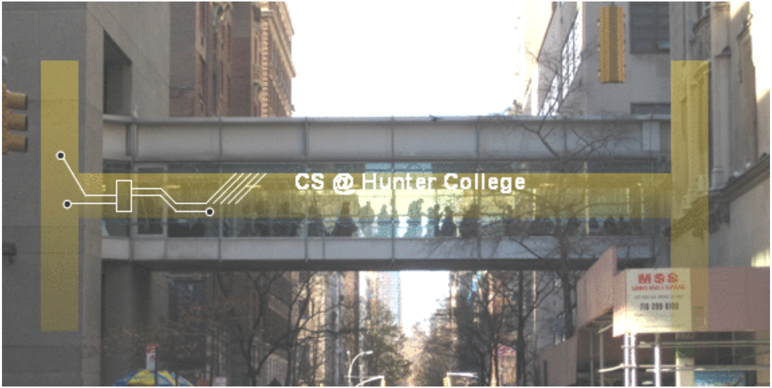
Forms for your choices ("pink slips") available next lecture.

Writing Boards



- Return writing boards as you leave...