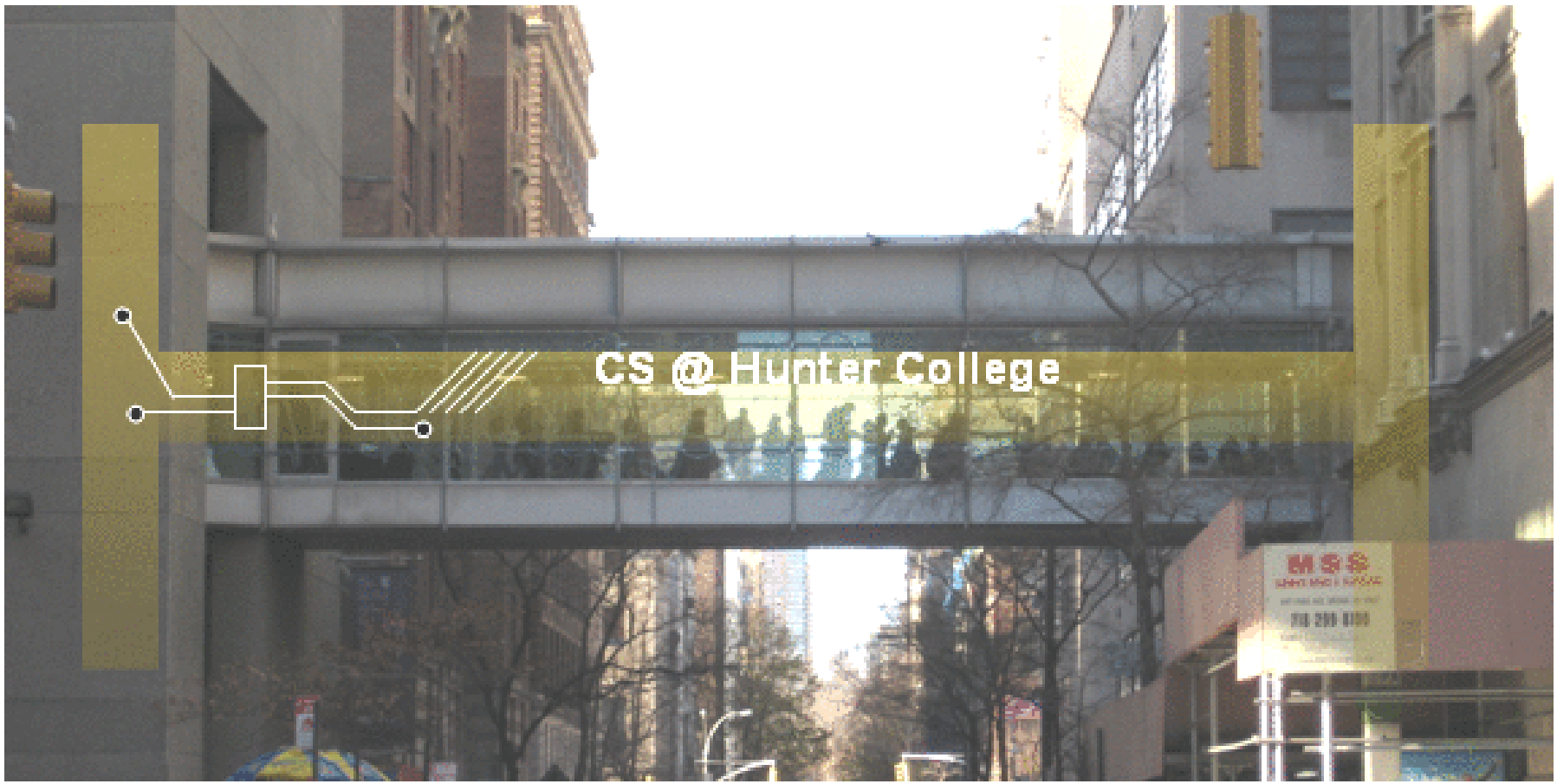
CSci 127: Introduction to Computer Science



hunter.cuny.edu/csci

Frequently Asked Questions

From email and tutoring.

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  - *All previous final exams (and answer keys) on the website.*
  - *UTAs in drop-in tutoring happy to review concepts and old exam questions.*
  - *There will be opportunity for practice during our last meeting on 13 December.*

Handle Exam Anxiety – courtesy Dr. St. John

- Print out the past exams and do as much as possible in 1 hour.
- Then grade yourselves, figure out which problems are similar to past problems, keeping all the exams youve done in a 3-hole notebook, 1 problem per page, organized by problem number, reinforces the similarity.
- Make a list of what does not make sense and asking the instructor.
- Attempting to do the exam in half the time means that in the real exam, you will have plenty of time.

Today's Topics

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

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Predict what the code will do:

```
1  def search(nums, locate):
2      found = False
3      i = 0
4      while not found and i < len(nums):
5          print(nums[i])
6          if locate == nums[i]:
7              found = True
8          else:
9              i = i+1
10
11     return(found)
```

Predict what the code will do: II

```
11 nums= [1,4,10,6,5,42,9,8,12]
12 target = 6
13 if search(nums, target):
14     print(target, 'is in the list.')
15 else:
16     print(target, 'is not in the list.')
```

Simplified but a little tricky

```
1  def search(nums, locate):
2      i = 0
3      while i < len(nums) and locate!=nums[i]:
4          print(nums[i])
5          i = i+1
6
7      return (i < len(nums))
8      #If locate is in the list,
9      #then for some i < len(nums), we have
10     #locate == nums[i].
11     #If i >= len(nums), this implies that all
12     #items are searched, no match is found.
```

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Design Pattern: Linear Search

```
def search(nums, locate):
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    i = 0
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        if locate == nums[i]:
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        else:
            i = i+1
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- Example of **linear search**.
- Start at the beginning of the list.
- Look at each item, one-by-one.

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- Start at the beginning of the list.
- Look at each item, one-by-one.
- Stop when found, or the end of lis reached.

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

Python & Circuits Review: 10 Weeks in 10 Minutes

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

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

```
1 #Texts following # are comments.
2 #Comments are read by human beings, not
     computer.
3 #Name: Thomas Hunter
4 #Date: September 1, 2017
5 #This program prints: Hello, World!
6
7 print("Hello, World!")
```

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

```
1  import turtle
2
3  taylor = turtle.Turtle()
4  taylor.color("purple")
5  taylor.shape("turtle")
6
7  n = 6
8  for i in range(n):
9      taylor.forward(100)
10     taylor.stamp()
11     taylor.left(360/n)
```

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

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  - **string**: sequence of characters
  - **list**: a sequence of items

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  - **list**: a sequence of items
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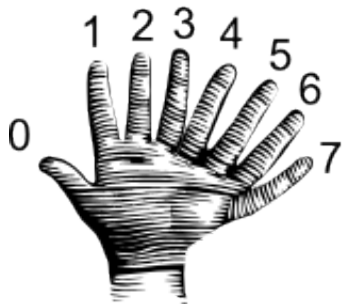
  - **class variables**: for complex objects, like turtles.
- More on loops & ranges:

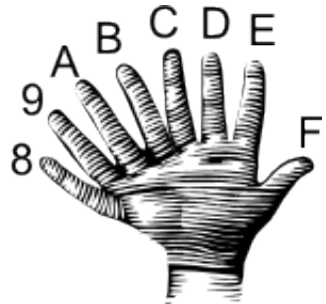
Examples on loop and ranges

```
1  for num in [2,4,6,8,10]:
2      print(num)
3
4  sum = 0
5  for x in range(0,12,2):
6      print(x)
7      sum += x
8
9  print(sum)
10
11 for c in 'ABCD':
12     print(c)
```

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

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





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Color Name	HEX	Color
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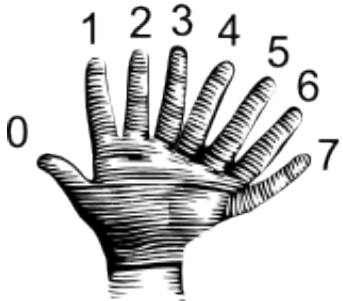

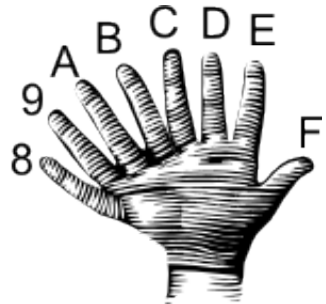

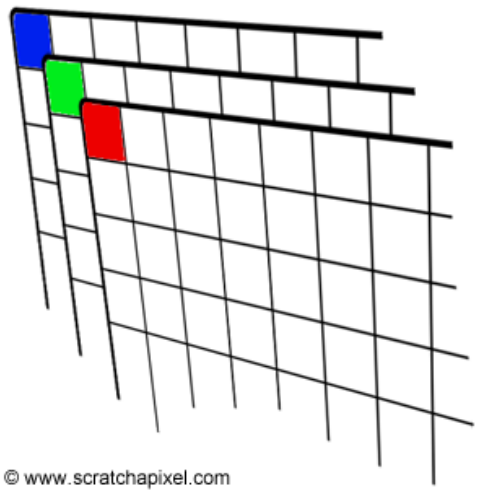

Two Dimensional Array Slicing

```
1 import numpy as np
2
3 numRows = 6
4 numCols = 6
5 a = np.zeros((numRows, numCols))
6 #create a table with 6 rows and 6 columns,
7 #each element is initialized to be zero.
8 #Do not forget parentheses around
9 #numRows, numCols.
```

Two Dimensional Array Slicing: II

```
8  for i in range(numRows):
9      for j in range(numCols):
10         a[i, j] = i*10 + j
11 #range(numRows) returns [0, 1, 2, 3, 4, 5],
12 #where outer loop variable i chooses from.
13 #When i is 0, run
14 #    for j in range(numCols):
15 #        a[i, j] = i*10 + j
16 #When i is 1, run
17 #    for j in range(numCols):
18 #        a[i, j] = i*10 + j
19 #The last round of i is 5.
```

Two Dimensional Array Slicing: III

```
20  for i in range(numRows):
21      for j in range(numCols):
22          print("%3i"%(a[i, j]), end="")
23          #"%3i"%(a[i, j]) prints a[i, j] --
24          #element of a at ith row and
25          #jth column -- as an 3-digit int.
26          #"%3i" is a place holder and is
                filled by a[i, j].
27          #If a[i, j] does not have 3 digits,
28          #pad space(s) to the left.
29          #end="" print w/o a new line.
30
31      print() #print a new line after each row
```

Two Dimensional Array Slicing: III

```
32 print(a[0, 3:5])
```

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

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```

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3	30	31	32	33	34	35
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row \ col	0	1	2	3	4	5
0	0	1	2	3	4	5
1	10	11	12	13	14	15
2	20	21	22	23	24	25
3	30	31	32	33	34	35
4	40	41	42	43	44	45
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print

```
[3. 4.]
```

Two Dimensional Array Slicing: IV

```
33 print(a[4:, 4:])
```

row \ col	0	1	2	3	4	5
0	0	1	2	3	4	5
1	10	11	12	13	14	15
2	20	21	22	23	24	25
3	30	31	32	33	34	35
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Two Dimensional Array Slicing: IV

```
33 print(a[4:, 4:])
```

row \ col	0	1	2	3	4	5
0	0	1	2	3	4	5
1	10	11	12	13	14	15
2	20	21	22	23	24	25
3	30	31	32	33	34	35
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row \ col	0	1	2	3	4	5
0	0	1	2	3	4	5
1	10	11	12	13	14	15
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3	30	31	32	33	34	35
4	40	41	42	43	44	45
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Print out

```
[[44. 45.]
 [54. 55.]]
```

Two Dimensional Array Slicing: V

```
34 print(a[:, 2])
```

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

Two Dimensional Array Slicing: V

```
34 print(a[:, 2])
```

row \ col	0	1	2	3	4	5
0	0	1	2	3	4	5
1	10	11	12	13	14	15
2	20	21	22	23	24	25
3	30	31	32	33	34	35
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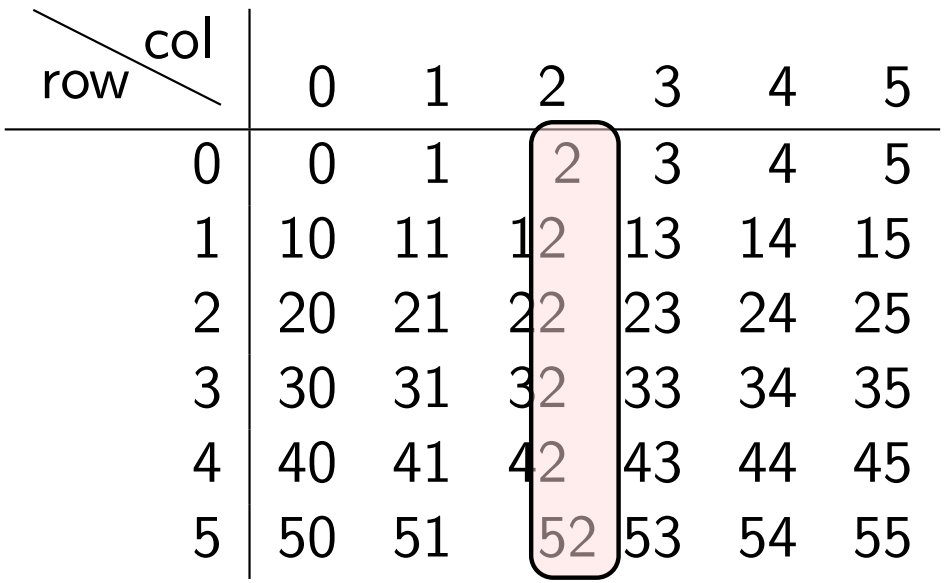

Print out

```
[ 2. 12. 22. 32. 42. 52.]
```

Two Dimensional Array Slicing: VI

35
```
print(a[2::2, ::2])
```

	0	1	2	3	4	5
0	0	1	2	3	4	5
1	10	11	12	13	14	15
2	20	21	22	23	24	25
3	30	31	32	33	34	35
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Two Dimensional Array Slicing: VI

35
```
print(a[2::2, ::2])
```

	0	1	2	3	4	5
0	0	1	2	3	4	5
1	10	11	12	13	14	15
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	0	1	2	3	4	5
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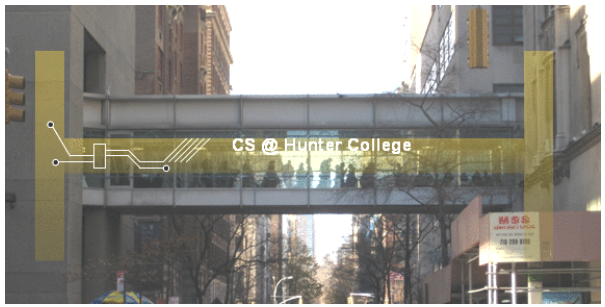
print

```
[[20. 22. 24.]
 [40. 42. 44.]]
```

Week 4: design problem (cropping images) & decisions



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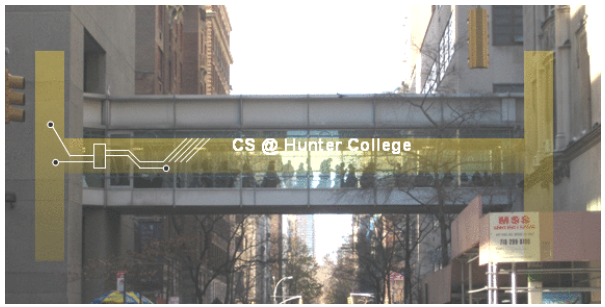

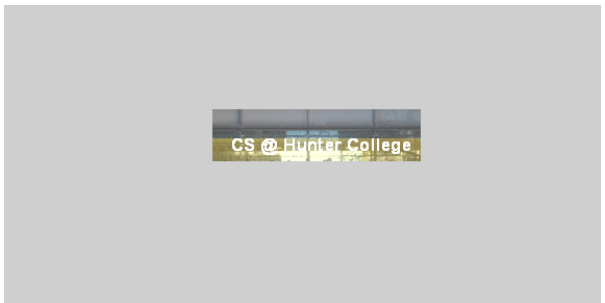

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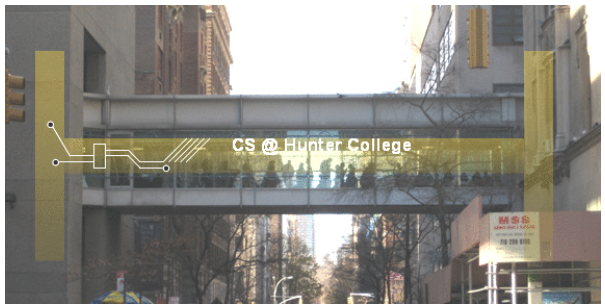

- First: specify inputs/outputs. *Input file name, output file name, upper, lower, left, right ("bounding box")*
- Next: write pseudocode.
  1. Import numpy and pyplot.
  2. Ask user for file names and dimensions for cropping.
  3. Save input file to an array.
  4. Copy the cropped portion to a new array.
  5. Save the new array to the output file.

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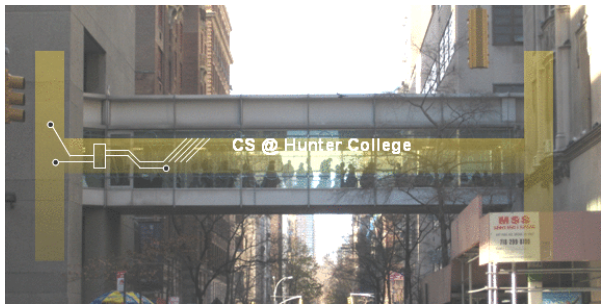

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- Next: translate to Python.

Grayed surrounding area of an image

```
1  #Leave middle 1/5 height * 1/2 width
       unchanged,
2  #gray the rest area of the image
3  import matplotlib.pyplot as plt
4  import numpy as np
5
6  fileName = input("Enter a file name: ")
7  img = plt.imread(fileName)
8
9  height = img.shape[0]
10 width = img.shape[1]
```

Grayed surrounding area of an image: II

```
11 #make the top 2/5 area gray
12 img[:height*2//5, :] = [0.5, 0.5, 0.5, 1]
13 #[0.5, 0.5, 0.5, 1] means
14 #red 0.5, green 0.5, blue 0.5 and opacity 1
15
16 #make the bottom 1/4 area gray
17 img[-height*2//5:, :] = [0.5, 0.5, 0.5, 1]
18 #img[ -height*2//5: , :] same as
19 #img[ height*3//5: , :]
20 ##height*2//5 from BOTTOM sams as
21 #height*3//5 from TOP
22 #img[height*3//5:, :] = [0.5, 0.5, 0.5, 1]
```

Grayed surrounding area of an image: III

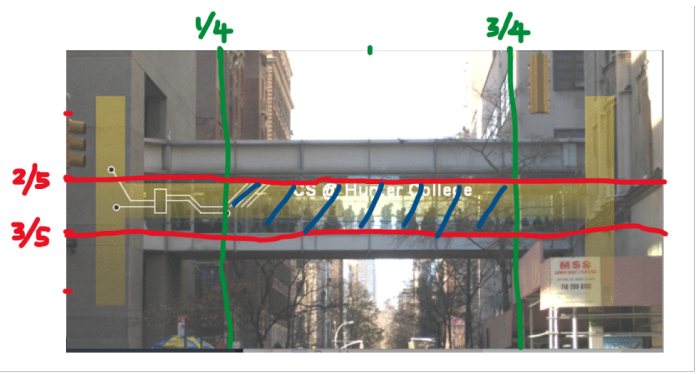
```
23 #make the left 1/4 area gray
24 img[:, :width//4] = [0.5, 0.5, 0.5, 1]
25
26 #make the right 1/4 area gray
27 img[:, width*3//4:] = [0.5, 0.5, 0.5, 1]
28 #img[:, width*3//4:] same as
29 #img[:, -width//4:]
30 #width*3//4 from LEFT same as
31 #width//4 from RIGHT
32 #img[:, -width//4:] = [0.5, 0.5, 0.5, 1]
33
34 plt.imshow(img)
35 plt.show()
```

Crop image

```
1  #crop middle 1/5 * height * 1/2 * width area
2  import matplotlib.pyplot as plt
3  import numpy as np
4
5  fileName = "csBridge.png"
6  #fileName = input("Enter a file name: ")
7  img = plt.imread(fileName)
8
9  height = img.shape[0]
10 width = img.shape[1]
```

Crop image: II

```
1 img2 = img[height*2//5 : height*3//5, width
    *1//4 : width*3//4] #// cannot be replaced
     by /, indices need to be int.
2
3 plt.imshow(img2)
4 plt.show()
5
6 plt.imsave('cropped_image.png', img2)
```



Week 4: design problem (cropping images) & decisions

```
1  yearBorn = int(input("Enter year born: "))
2  if yearBorn < 1946:
3      print("Greatest Generation")
4  elif yearBorn <= 1964:
5      print("Baby Boomer")
6  elif yearBorn <= 1984:
7      print("Generation X")
8  elif yearBorn <= 2004:
9      print("Millennial")
10 else:
11     print("TBD")
```

Week 4: design problem (cropping images) & decisions: II

```
1  x = int(input("Enter number: "))
2
3  if x % 2 == 0:
4      print("Even number")
5  else:
6      print("Odd number")
```

Week 5: logical operators, truth tables & logical circuits

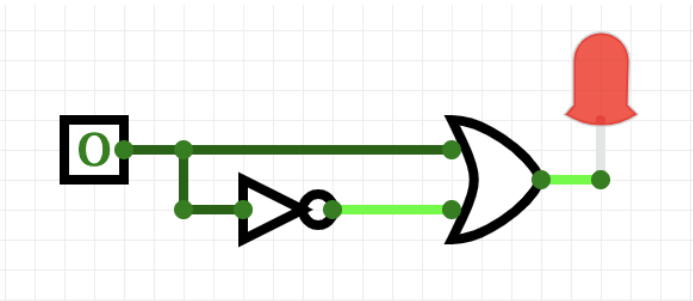
```
1  origin = "Indian Ocean"
2  winds = 100
3  if winds >= 74:
4      print("Major storms, called a ", end="")
5      if origin == "Indian Ocean" or origin == "
           South Pacific":
6          print("cyclone.")
7      elif origin == "North Pacific":
8          print("typhoon.")
9      else:
10         print("hurricane.")
```

Week 5: logical operators, truth tables & logical circuits: II

```
1 visibility = 0.2
2 winds = 40
3 conditions = "blowing snow"
4 if (winds > 35) and (visibility < 0.25) and
5    (conditions == "blowing snow" or
        conditions == "heavy snow"):
6    print("Blizzard!")
```

Week 5: logical operators, truth tables & logical circuits: III

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

```
import matplotlib.pyplot as plt
import pandas as pd
```

```
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```

`nycHistPop.csv`

In Lab 6

Week 6: structured data, pandas, & more design

```
import matplotlib.pyplot as plt
import pandas as pd

pop = pd.read_csv('nycHistPop.csv',skiprows=5)
```

```
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In Lab 6

Week 6: structured data, pandas, & more design

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nycHistPop.csv

In Lab 6

```
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import pandas as pd

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

pop.plot(x="Year")
plt.show()
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Week 6: structured data, pandas, & more design

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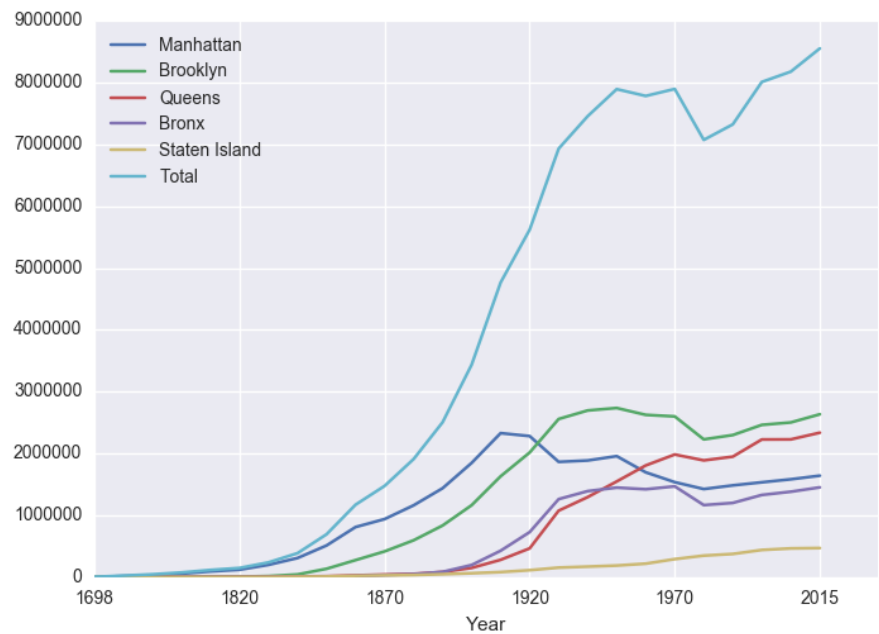
nycHistPop.csv

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()
```

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

Week 7: functions

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

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- You **call** or **invoke** a function by typing its name, followed by any inputs, surrounded by parenthesis:

Week 7: functions

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Week 7: functions

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Week 7: functions

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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: '))
dTip = float(input('Enter dinner tip:' ))
dTotal = totalWithTax(dinner, dTip)
print('Dinner total is', dTotal)
```

Week 8: function parameters, github

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- Surrounded by parenthesis, both in the function definition, and in the function call (invocation).

Week 8: function parameters, github

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

Week 8: function parameters, github

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Week 8: function parameters, github

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- Functions can also **return values** to where it was called.

Week 8: function parameters, github

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Formal Parameters

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


```
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: '))

print('The distance entered is', dist)
```

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

```
import turtle
import random

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

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

Week 10: more on loops, max design pattern, random()

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- Very useful for checking user input for correctness.

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- Python's built-in random package has useful methods for generating random whole numbers and real numbers.

```
import turtle
import random

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

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

Week 10: 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: '))

print('The distance entered is', dist)
```

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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.

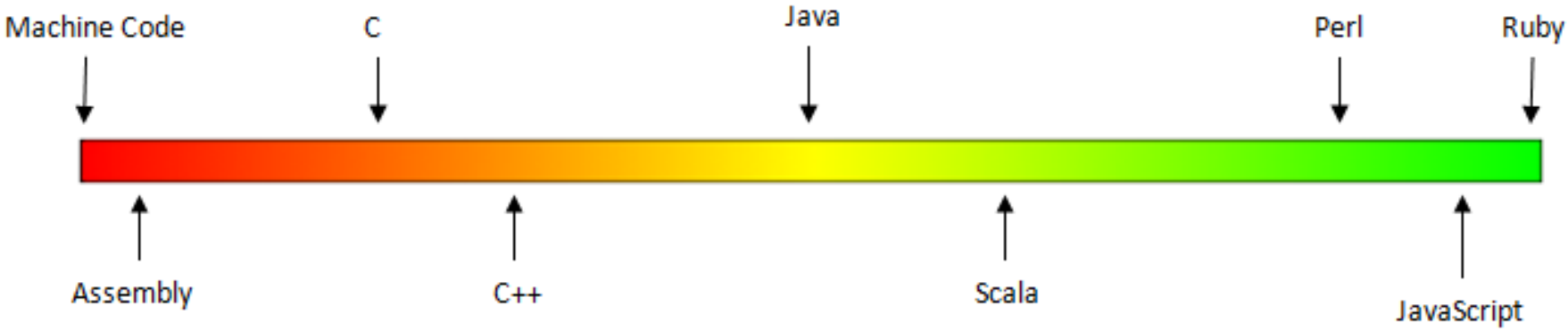
Python & Circuits Review: 10 Weeks in 10 Minutes

- 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

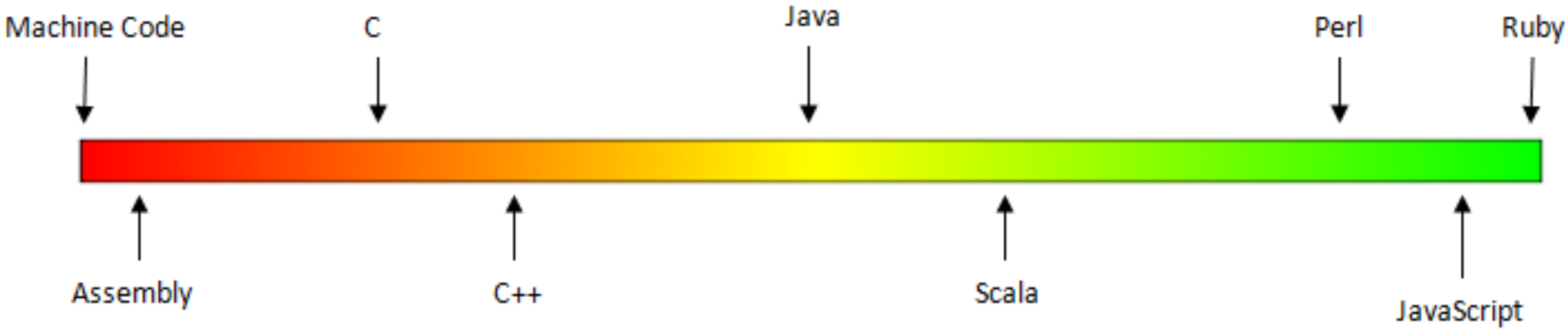
Low-Level vs. High-Level Languages



(codeCommit)

- Can view programming languages on a continuum.

Low-Level vs. High-Level Languages



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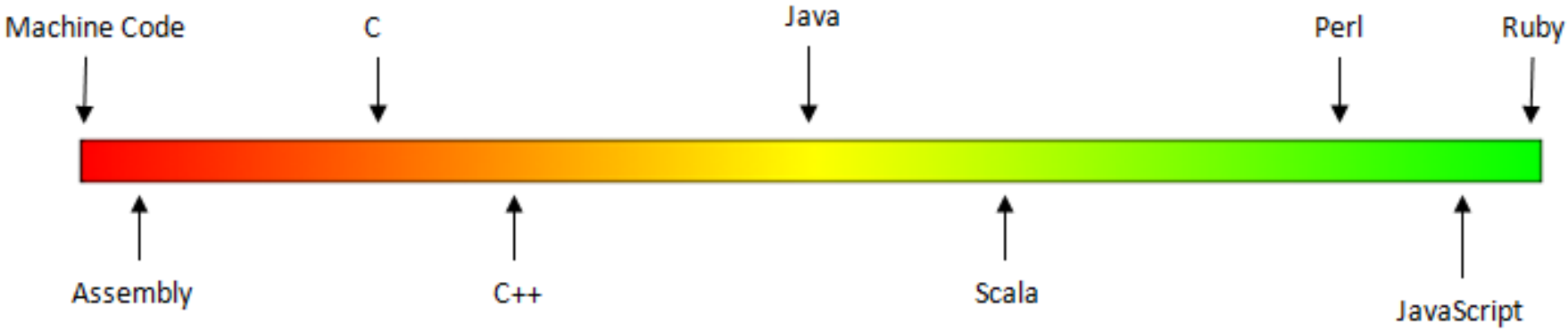
Low-Level vs. High-Level Languages



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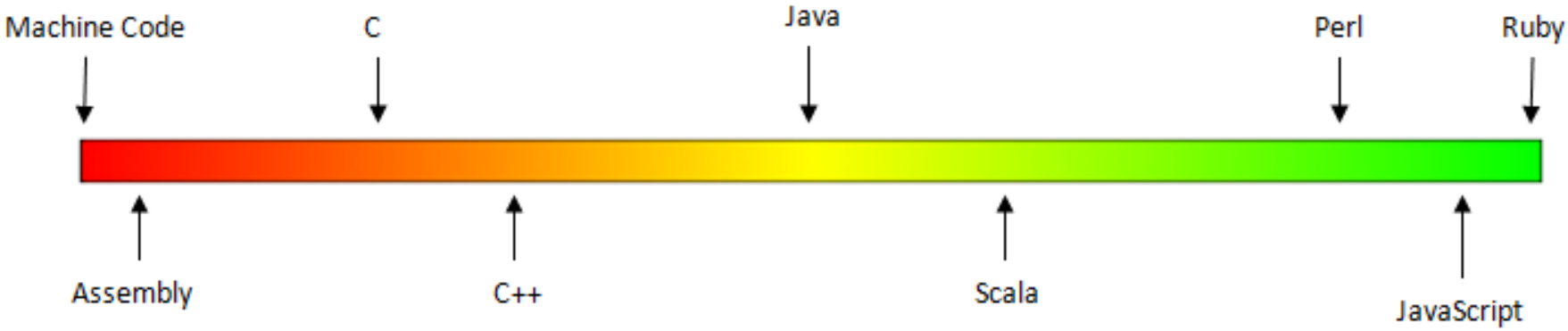

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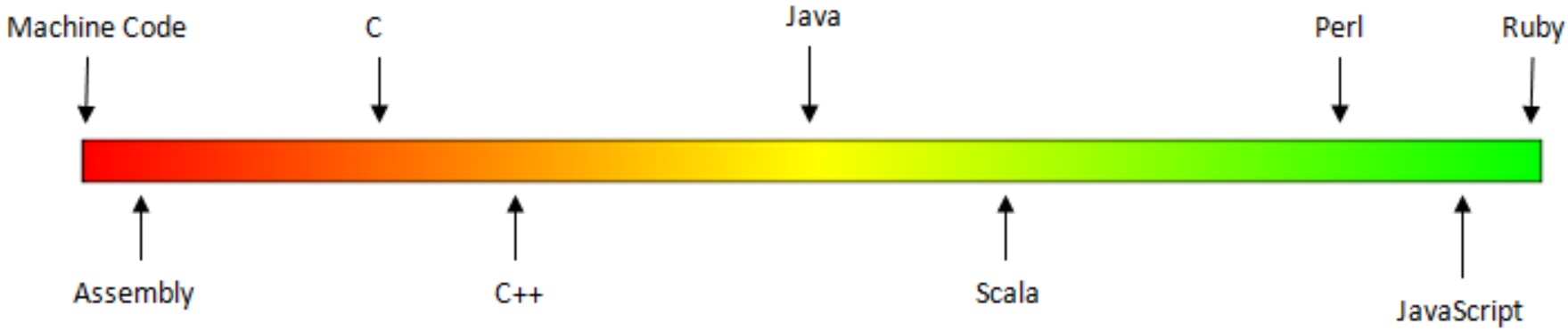
- Those that have strong abstraction (allow programming paradigms independent of the machine details, such as complex variables, functions and looping that do not translate directly into machine code) are called **high-level languages**.

Low-Level vs. High-Level Languages



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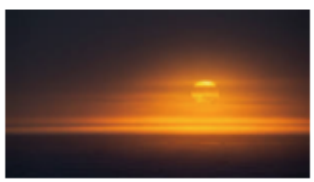
- Some languages, like C, are in between– allowing both low level access and high level data structures.

Processing

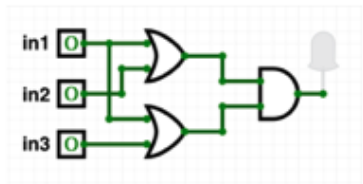
Dies ist ein Blindtext. An ihm lässt sich vieles über die Schrift ablesen, in der er gesetzt ist. Auf den ersten Blick wird der Grauwert der Schriftfläche sichtbar. Dann kann man prüfen, wie gut die Schrift zu lesen ist und wie sie auf den Leser wirkt.



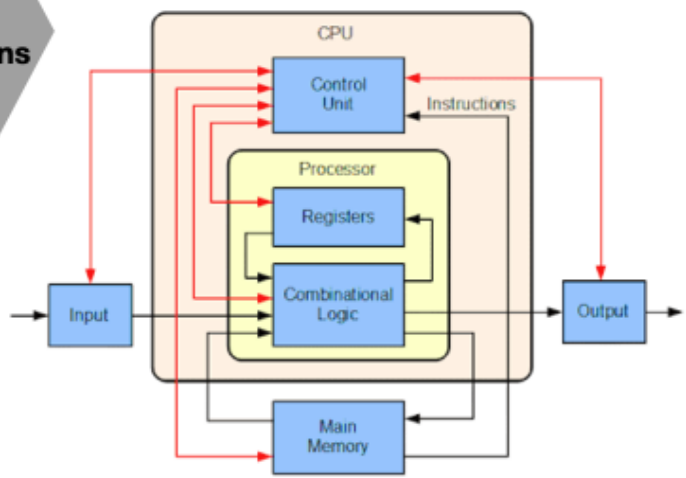
```
def totalWithTax(food,tip):
    total = 0
    tax = 0.0875
    total = food + food * tax
    total = total + tip
    return(total)
```

Data & Instructions

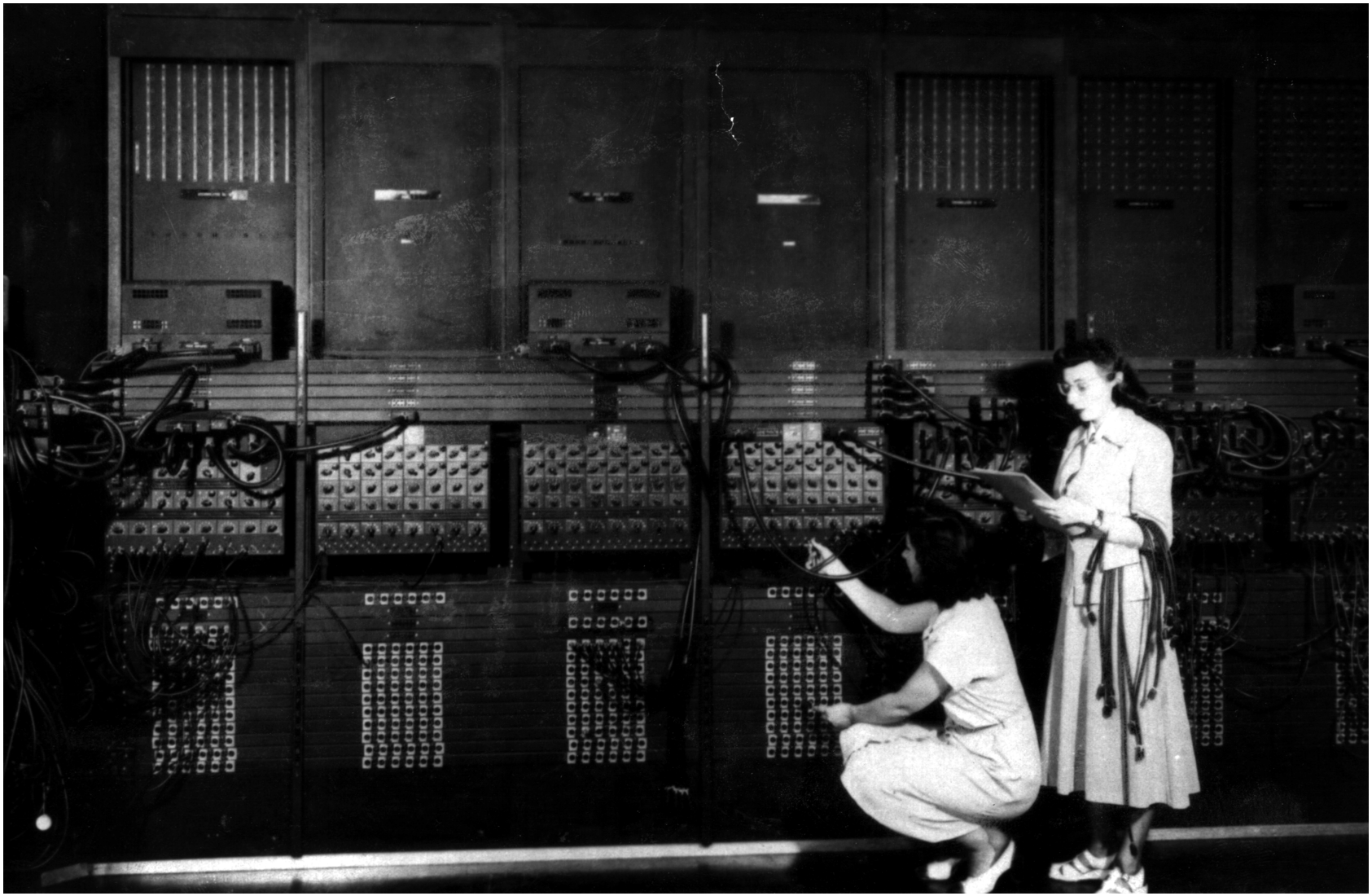
Data & Instructions



Circuits (switches)
On/Off 1/0 Logic
Billions of switches/bits

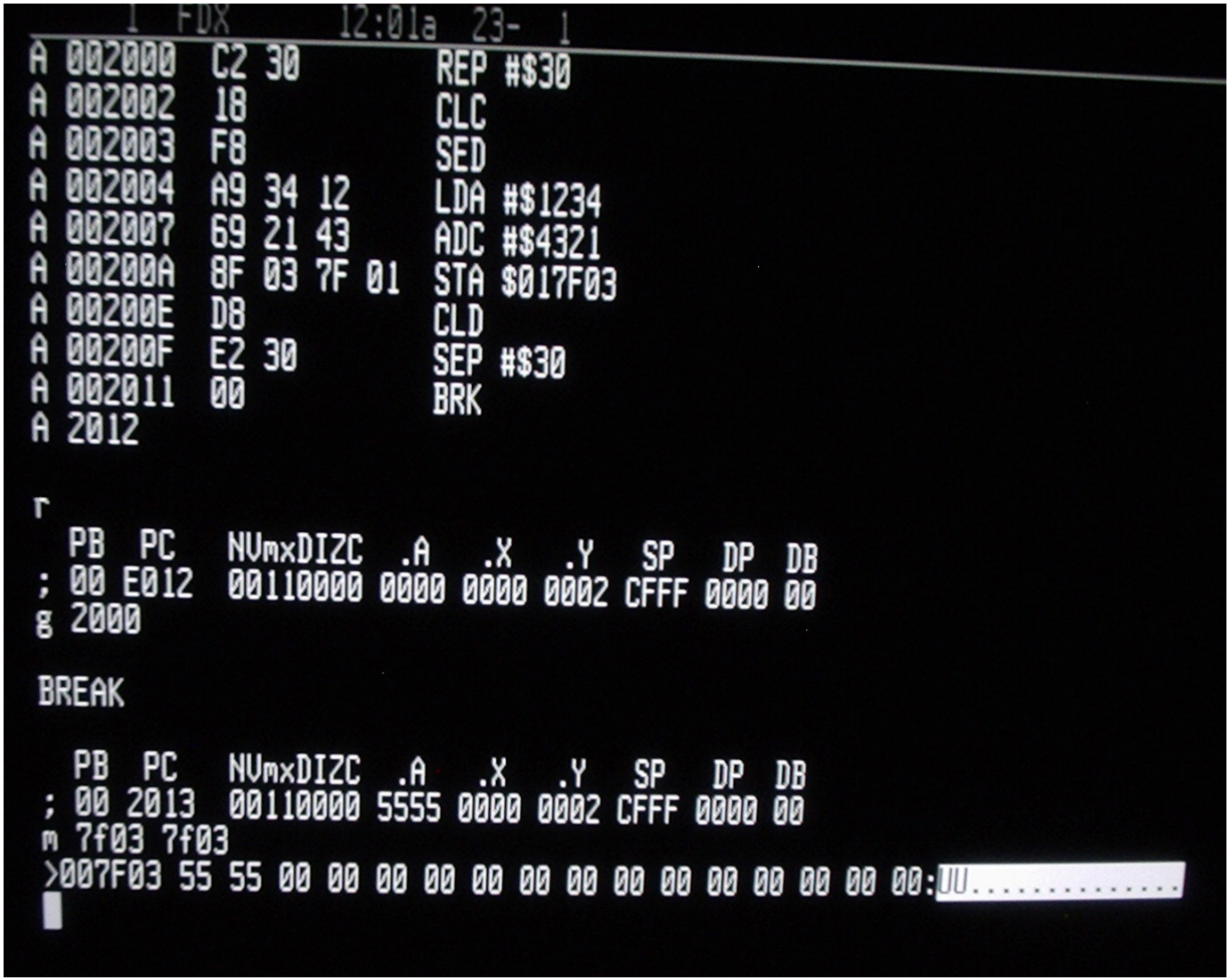


Machine Language



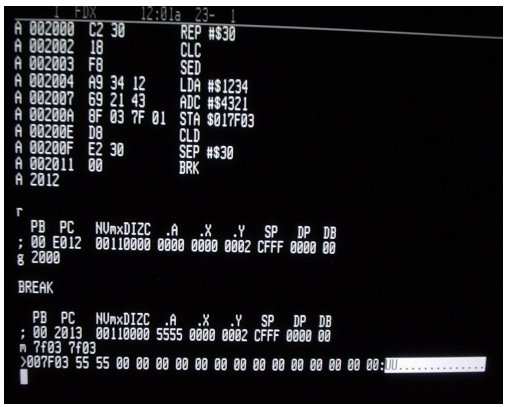
(Ruth Gordon & Ester Gerston programming the ENIAC, UPenn)

Machine Language



(wiki)

Machine Language



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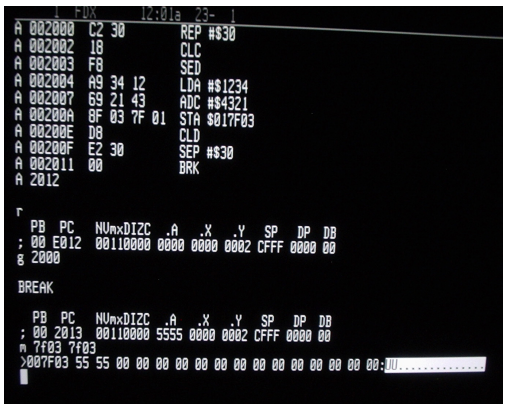
- We will be writing programs in a simplified machine language, WeMIPS.

Machine Language



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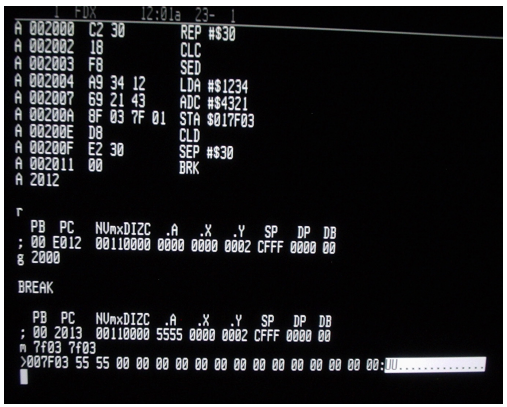
Machine Language



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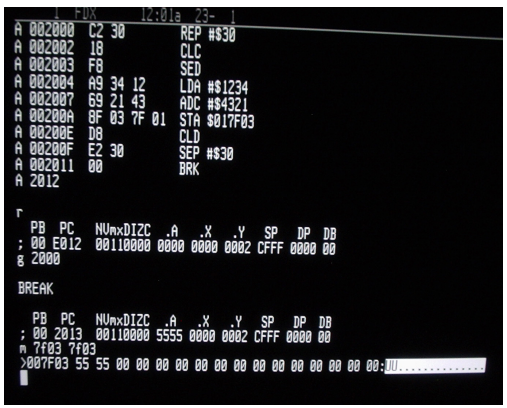
Machine Language



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

"Hello World!" in Simplified Machine Language

```
1  # Store 'Hello world!' at the top of the
       stack
2  ADDI $sp, $sp, -13
3  ADDI $t0, $zero, 72 # 72 is ASCII code of 'H'
4  SB $t0, 0($sp)
5  ADDI $t0, $zero, 101 # e
6  SB $t0, 1($sp)
7  ADDI $t0, $zero, 108 # l
8  SB $t0, 2($sp)
9  ADDI $t0, $zero, 108 # l
10 SB $t0, 3($sp)
11 ADDI $t0, $zero, 111 # o
12 SB $t0, 4($sp)
```

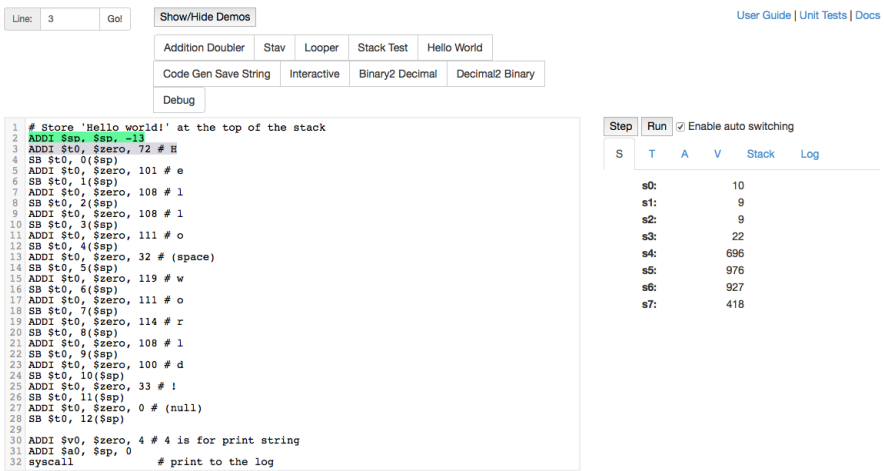
"Hello World!" in Simplified Machine Language: II

```
13 ADDI $t0, $zero, 32 # (space)
14 SB $t0, 5($sp)
15 ADDI $t0, $zero, 119 # w
16 SB $t0, 6($sp)
17 ADDI $t0, $zero, 111 # o
18 SB $t0, 7($sp)
19 ADDI $t0, $zero, 114 # r
20 SB $t0, 8($sp)
21 ADDI $t0, $zero, 108 # l
22 SB $t0, 9($sp)
23 ADDI $t0, $zero, 100 # d
24 SB $t0, 10($sp)
```

"Hello World!" in Simplified Machine Language: II

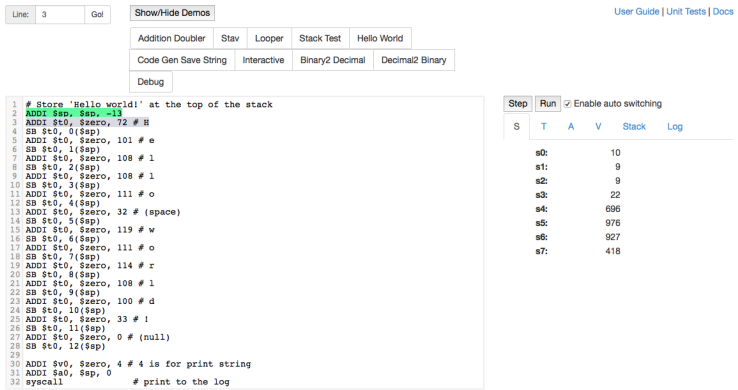
```
25 ADDI $t0, $zero, 33 # !
26 SB $t0, 11($sp)
27 ADDI $t0, $zero, 0 # (null)
28 SB $t0, 12($sp)
29
30 ADDI $v0, $zero, 4 # 4 is for print string
31 ADDI $a0, $sp, 0
32 syscall              # print to the log
```

WeMIPS



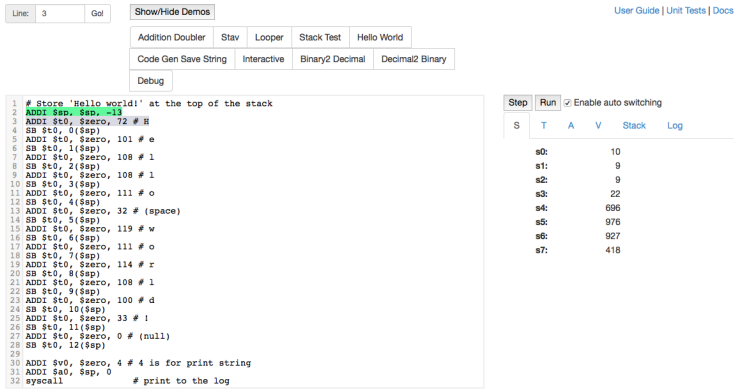
(Demo with WeMIPS)

MIPS Commands



- **Registers:** locations for storing information that can be quickly accessed.

MIPS Commands



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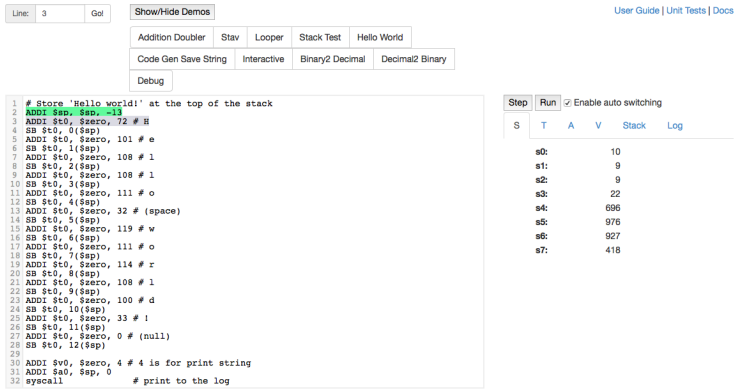

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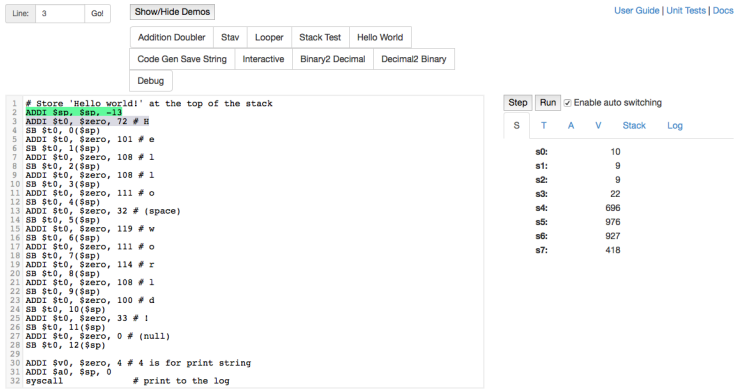
MIPS Commands



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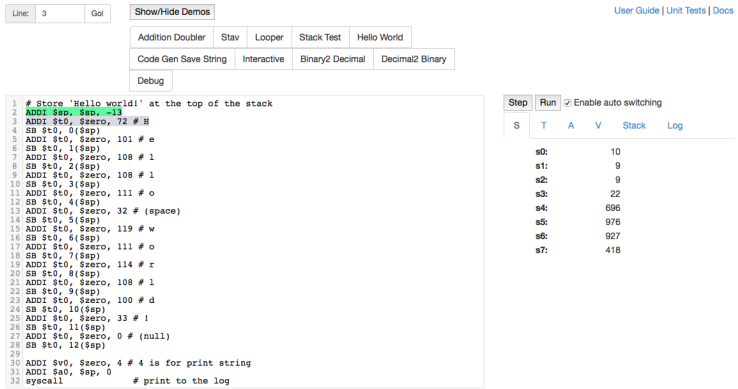
MIPS Commands



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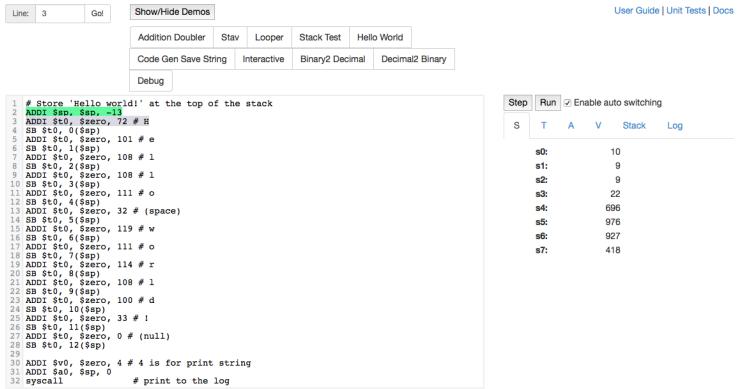
MIPS Commands



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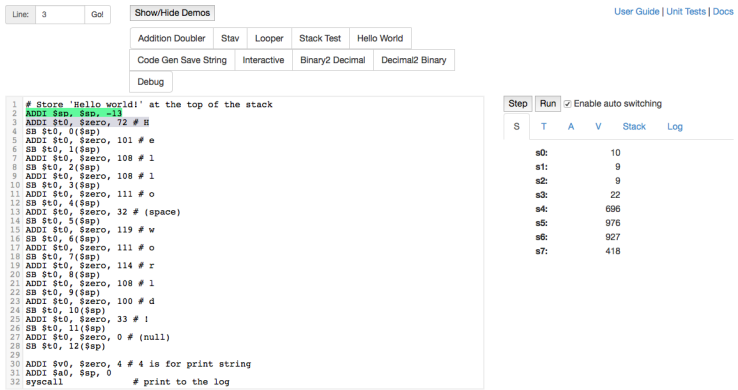
MIPS Commands



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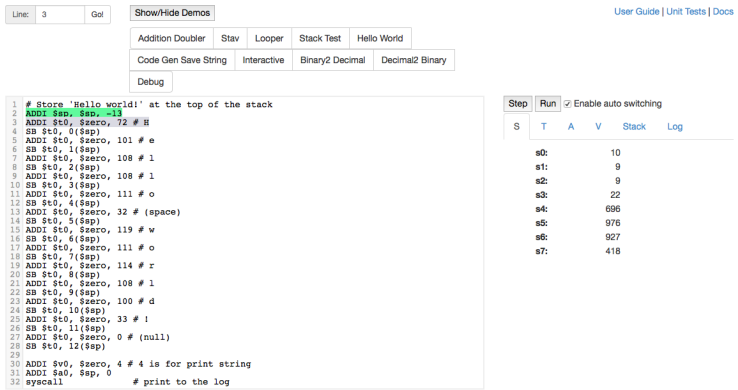

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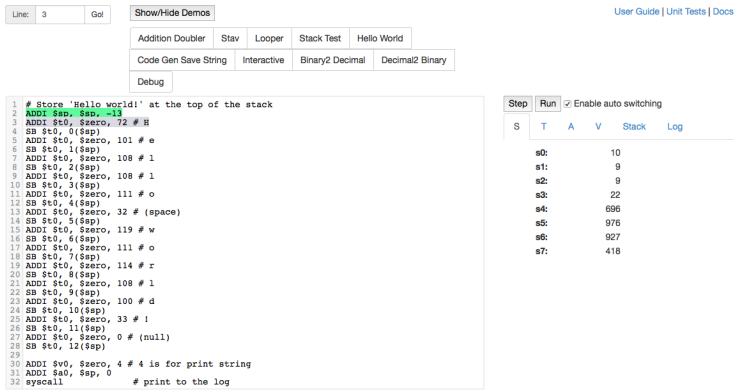
MIPS Commands



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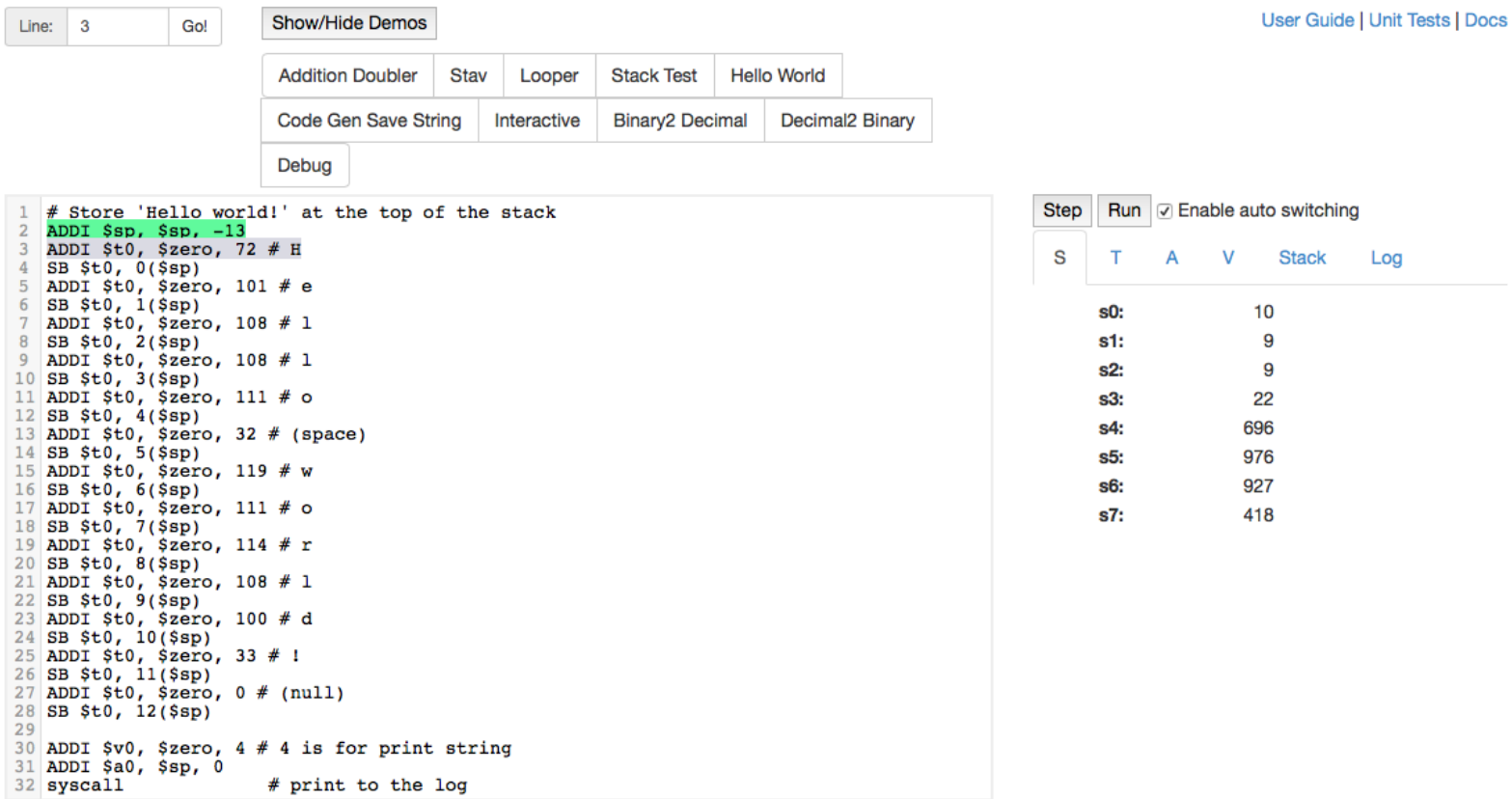
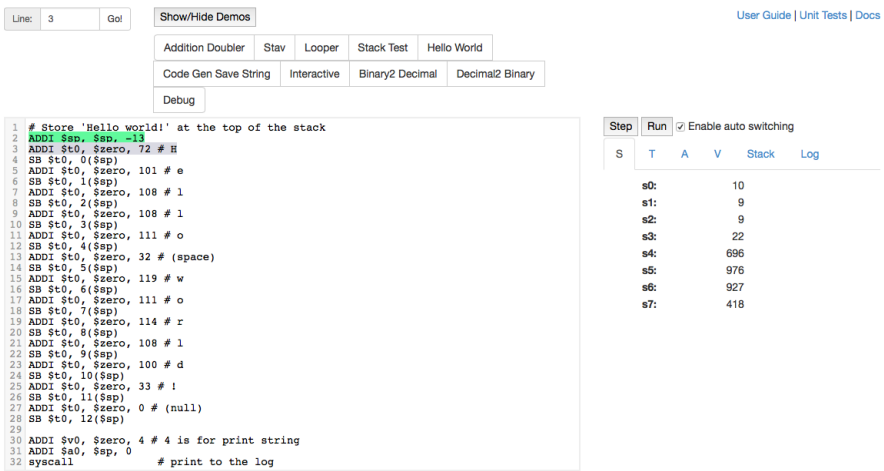
  `j done` (Basic form: `OP label`)

Challenge:



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

WeMIPS



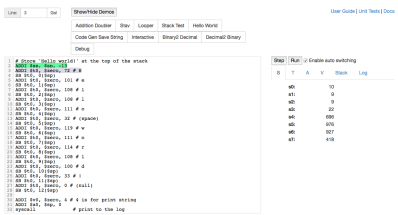
(Demo with WeMIPS)

Today's Topics

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

Loops & Jumps in Machine Language

- Instead of built-in looping structures like `for` and `while`, you create your own loops by "jumping" to the location in the program.



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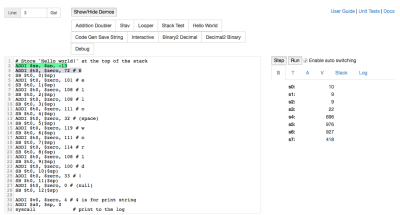
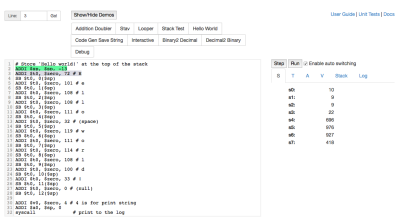


Loops & Jumps in Machine Language



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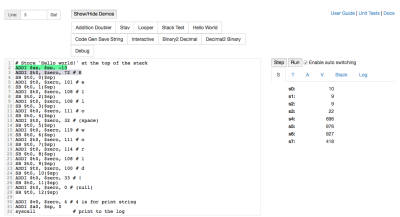
Loops & Jumps in Machine Language



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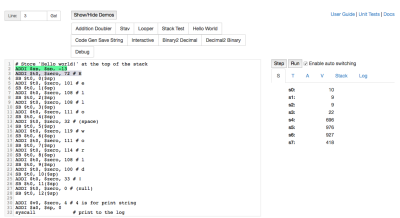
- Then give a command to jump to that location.
- Different kinds of jumps:

Loops & Jumps in Machine Language



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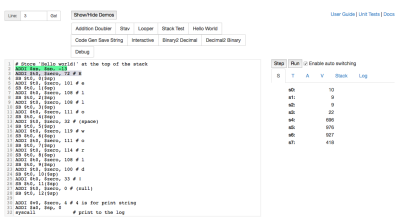
Loops & Jumps in Machine Language



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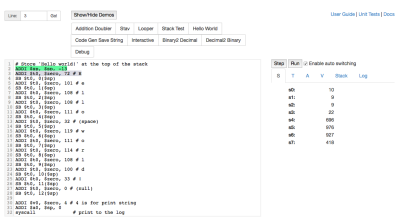

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  - See reading for more variations.

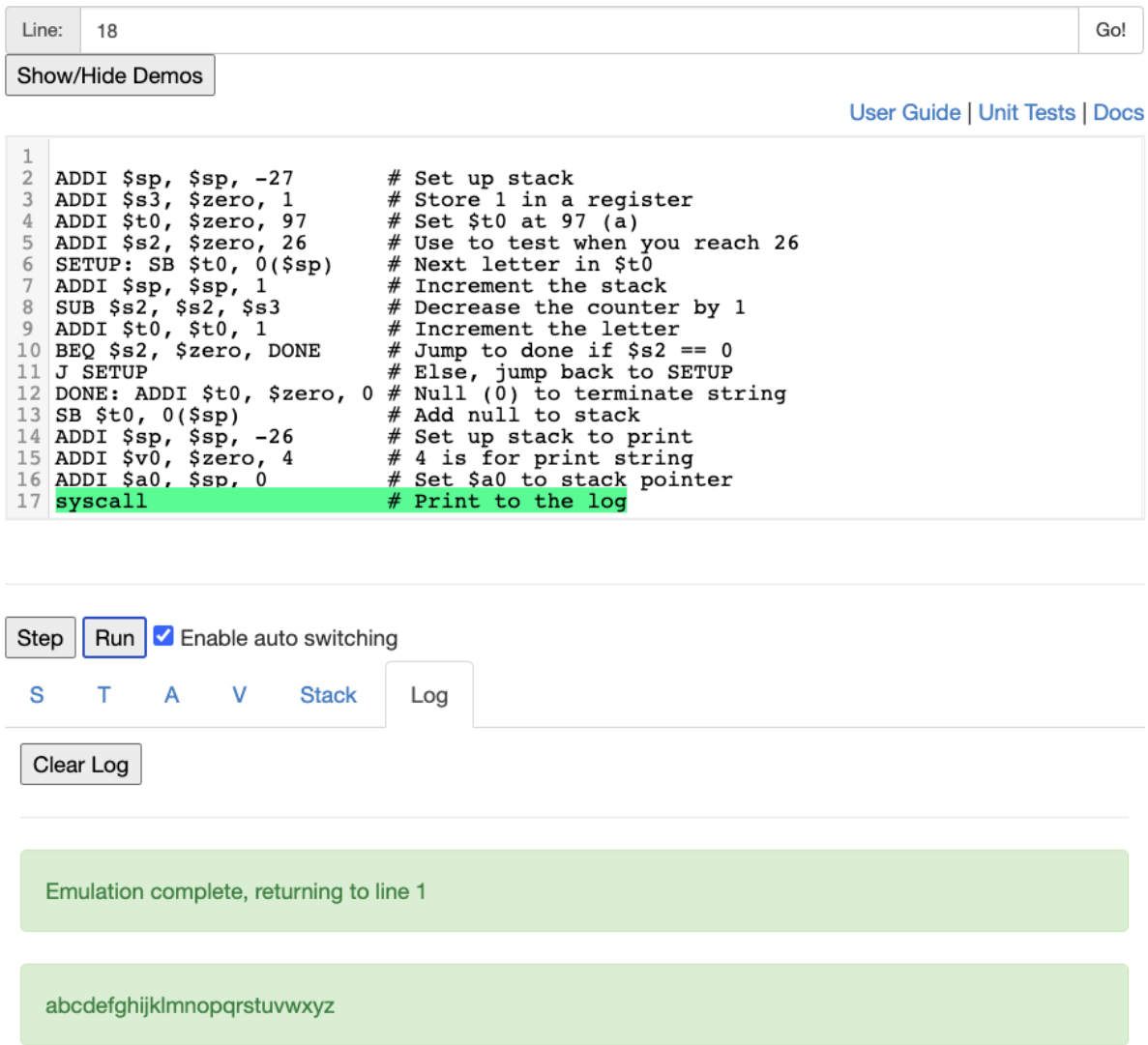
Print alphabet table in Simplified Machine Language: II

```
1 ADDI $sp, $sp, -27 #setup stack, 26 letters + 1 null
2 ADDI $t0, $zero, 97 #save ASCII of 'a' to $t0
3 ADDI $s2, $zero, 26 #set $s2 to be 26, track whether 26 is reached or not
4 SETUP:SB $t0, 0($sp) #save contents of $t0 to stack
5 ADDI $sp, $sp, 1 #increment the stack
6 ADDI $s2, $s2, -1 #subtract 1 from $s2
7 ADDI $t0, $t0, 1 #increment the letter
8 BEQ $s2, $zero, DONE
9 J SETUP
```

Print alphabet table in Simplified Machine Language: II

```
10 DONE:ADDI $t0, $zero, 0 #set null
11 SB $t0, 0($sp)
12 ADDI $sp, $sp, -26
13 ADDI $v0, $zero, 4 #$v0 is 4 means to print
14 ADDI $a0, $sp, 0 #set $a0 to stack pointer
15 syscall
```

Jump Demo

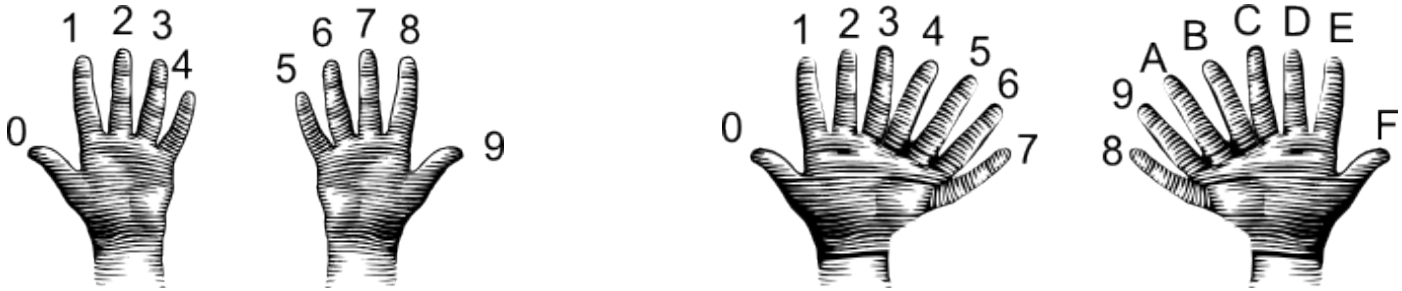


(Demo with `WeMIPS`)

Today's Topics

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

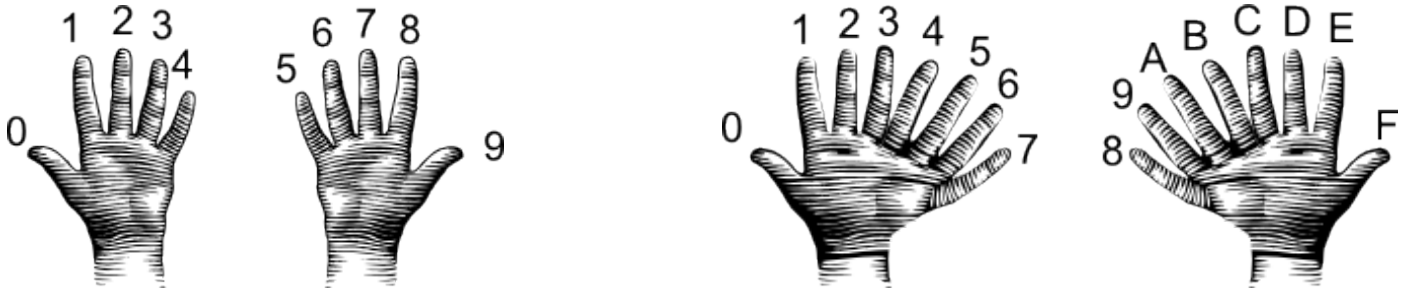
Hexadecimal to Decimal: Converting Between Bases



(from i-programmer.info)

- From hexadecimal to decimal (assuming two-digit numbers):
  - Convert first digit to decimal and multiple by 16.

Hexadecimal to Decimal: Converting Between Bases



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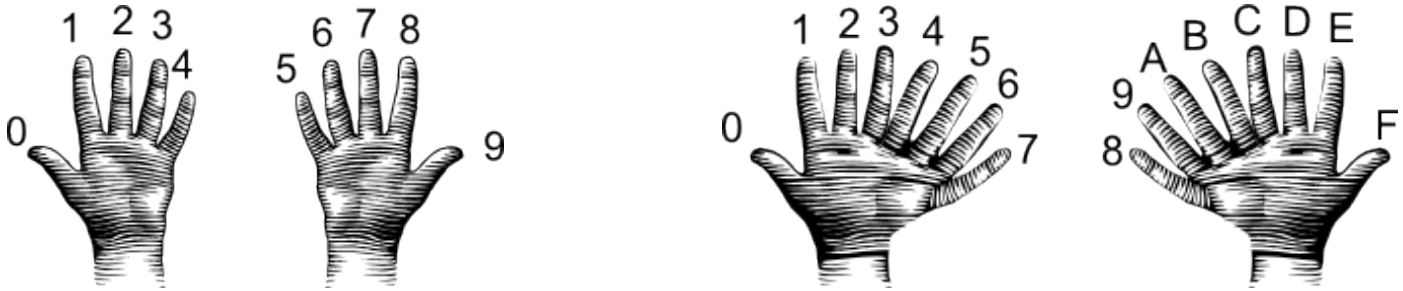

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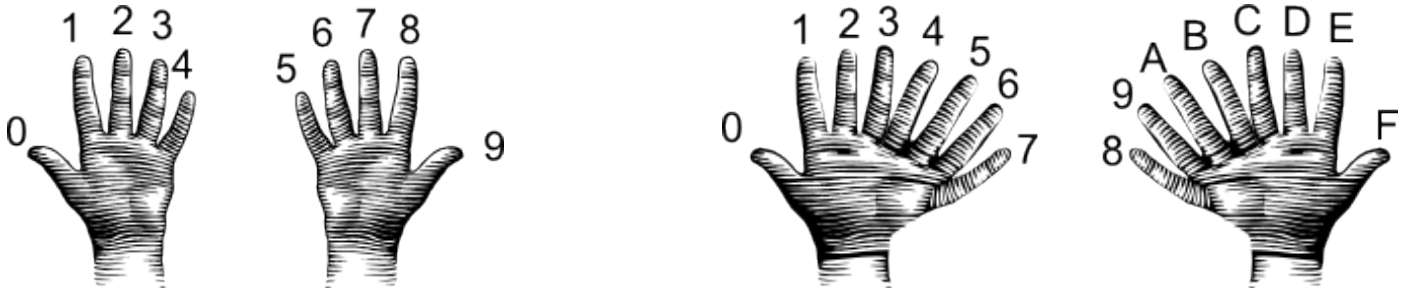

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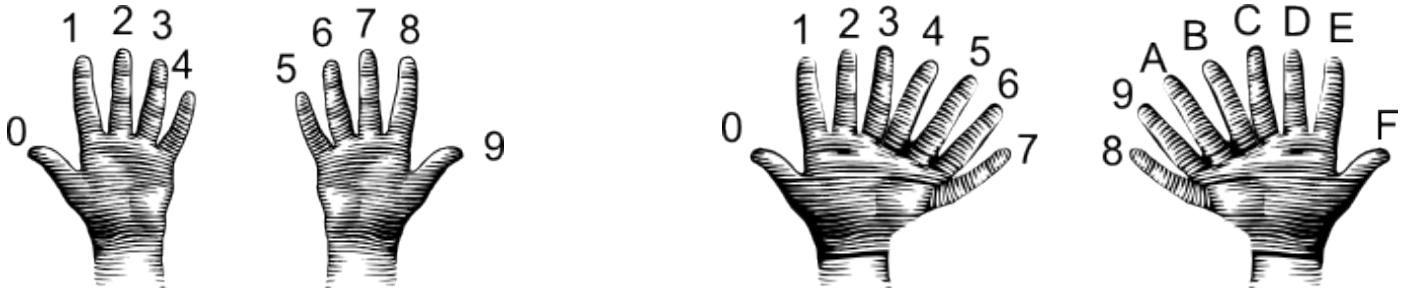

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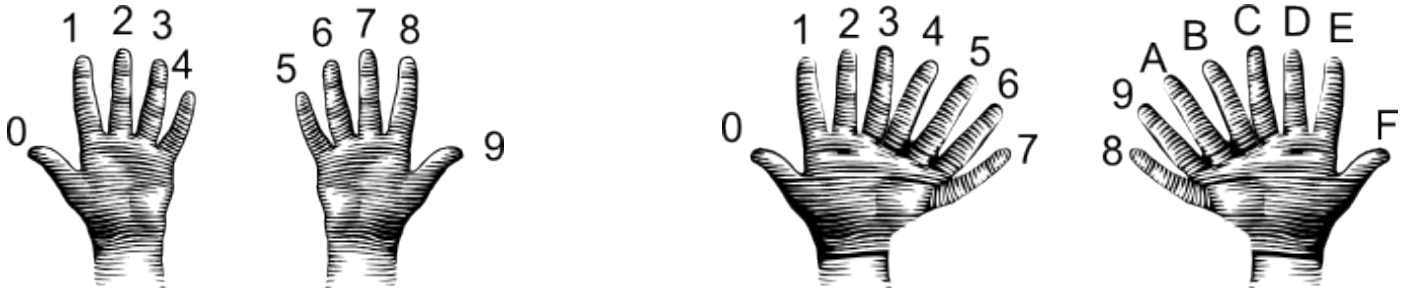

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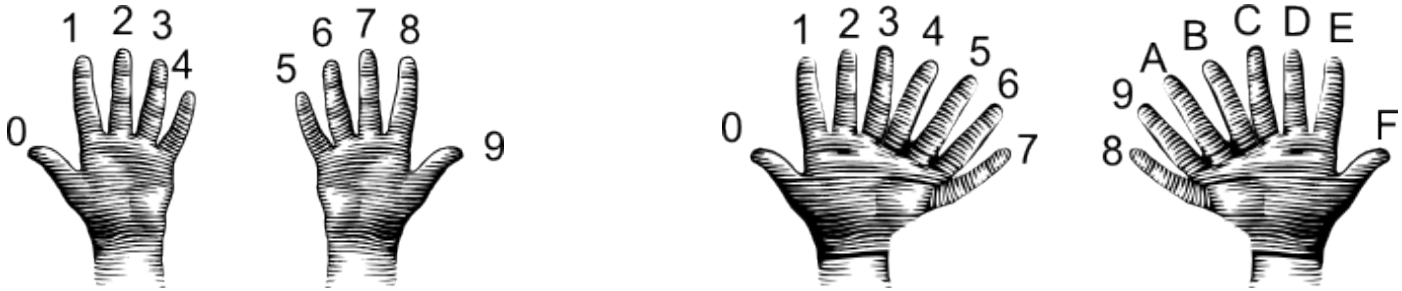

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    2 in decimal is 2. 2*16 is 32.
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    32 + 10 is 42.
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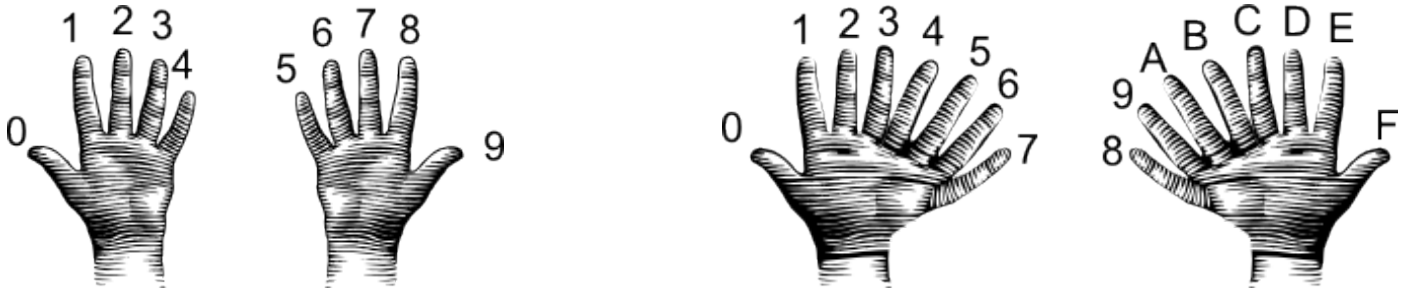

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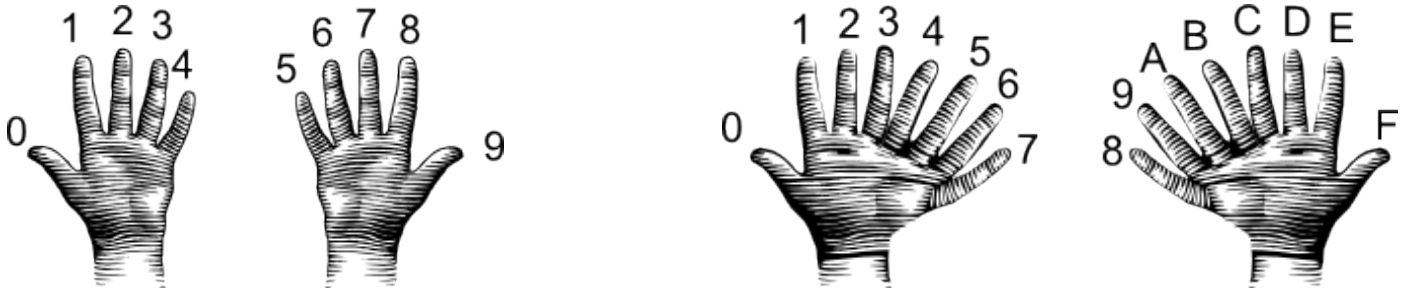

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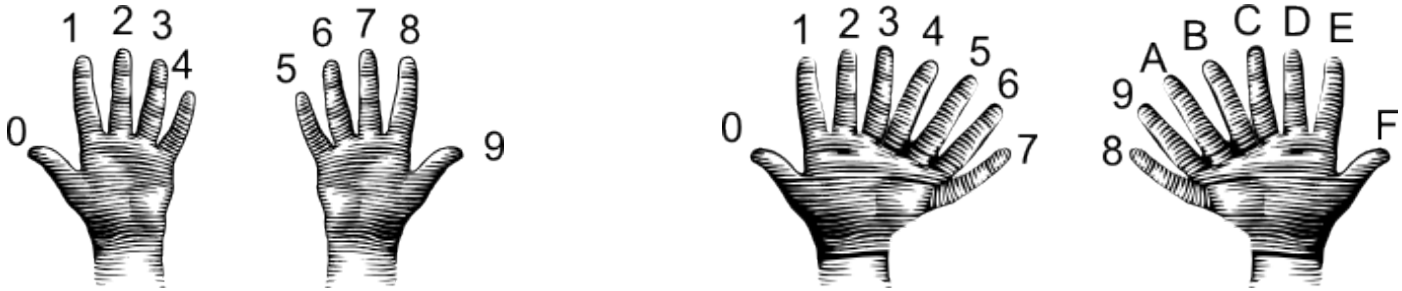

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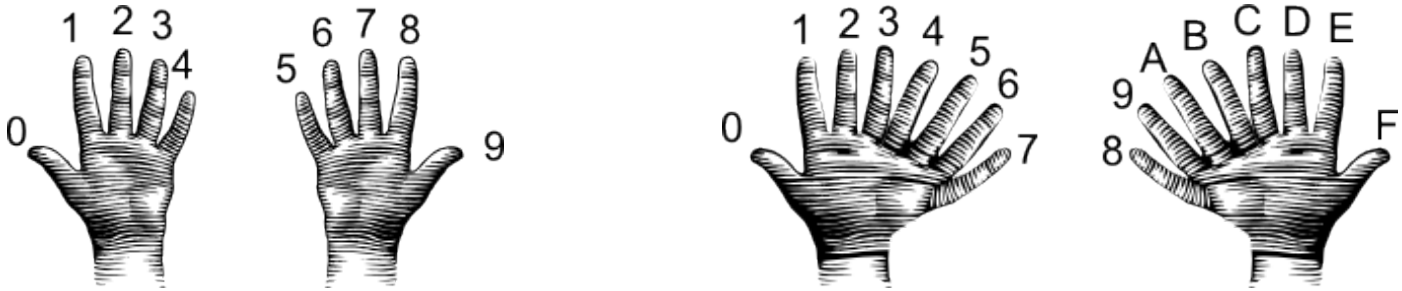

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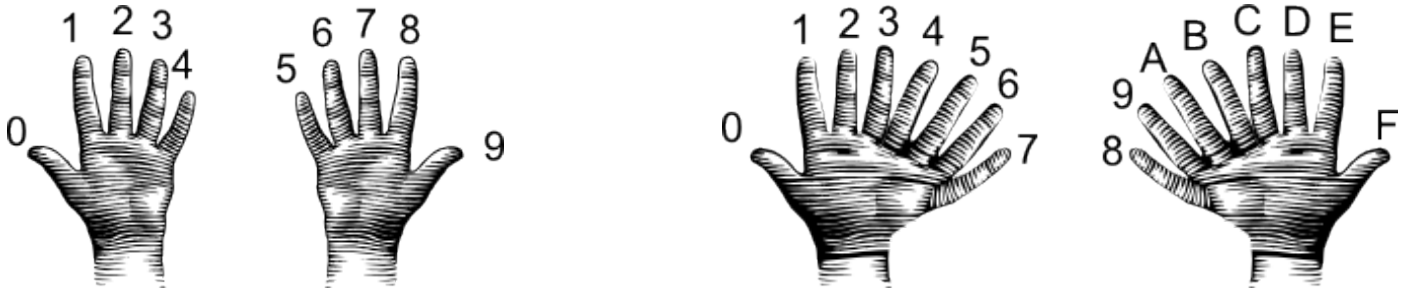

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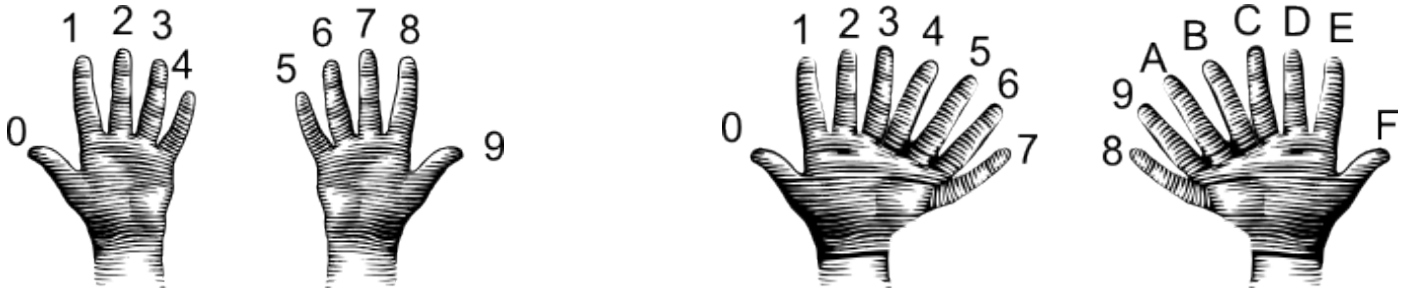

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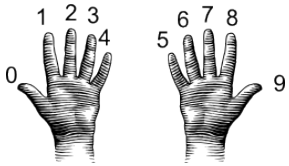

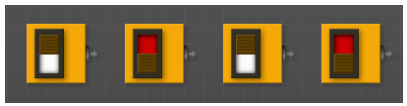

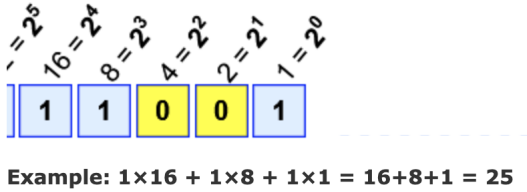

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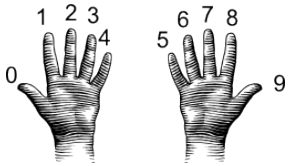

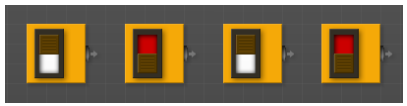

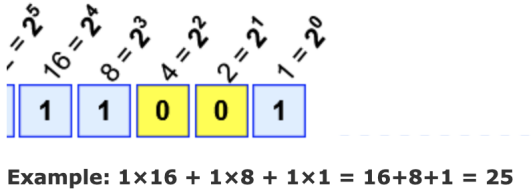

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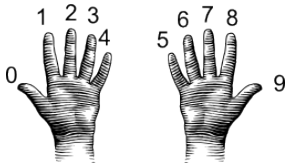

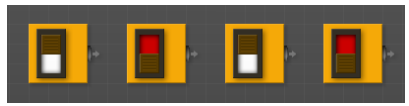

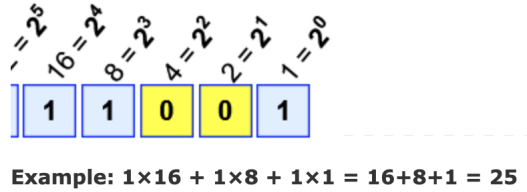

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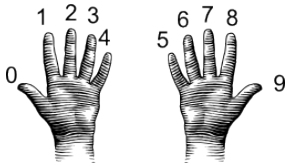

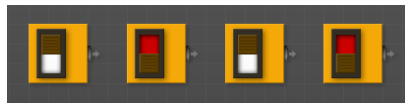

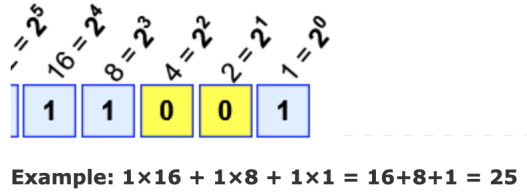

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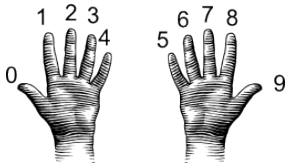

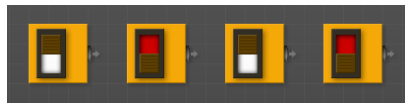

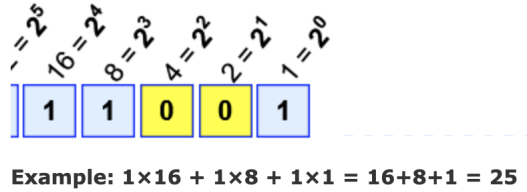

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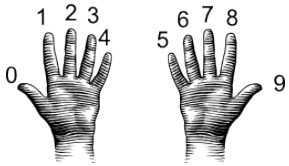

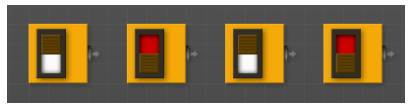

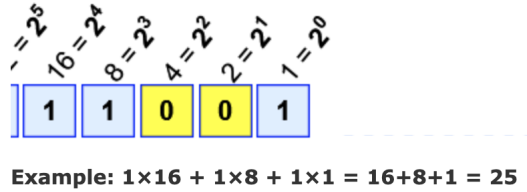

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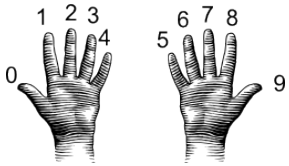

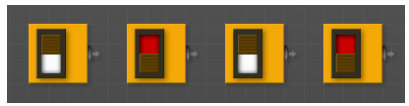

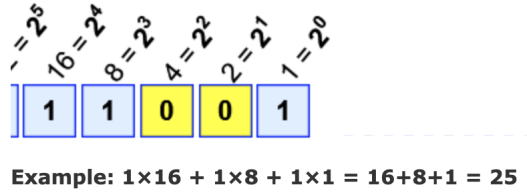

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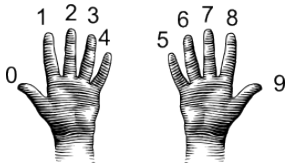

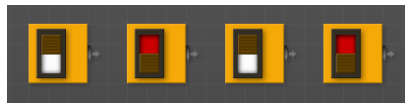

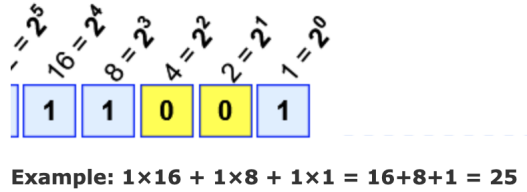

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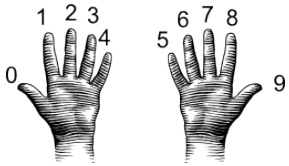

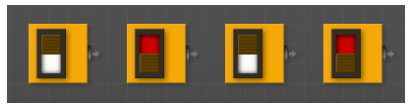

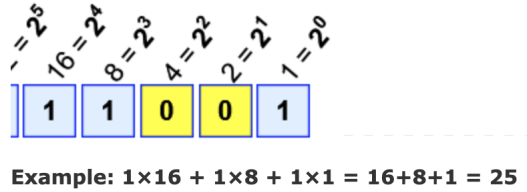

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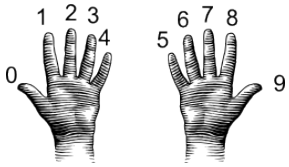

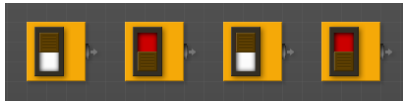

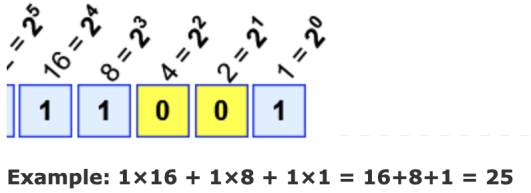

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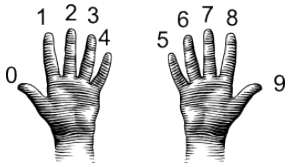

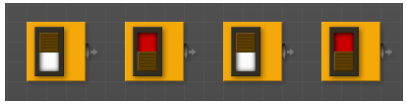

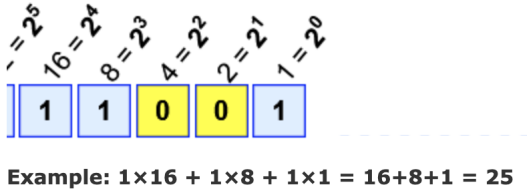

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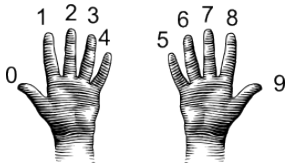

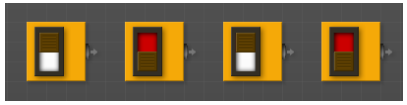

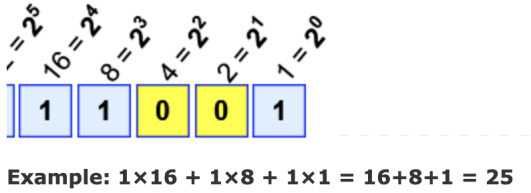

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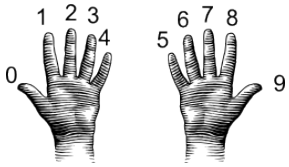

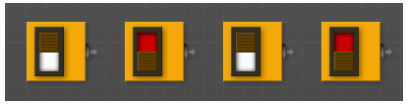

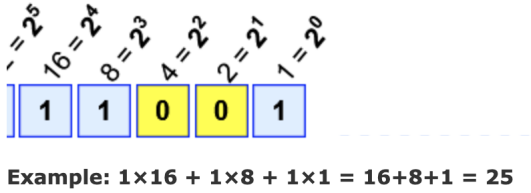

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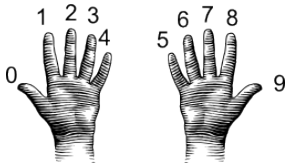

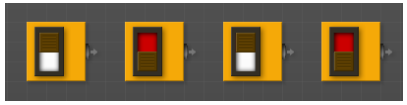

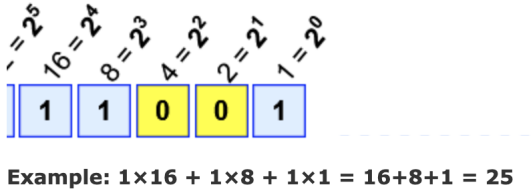

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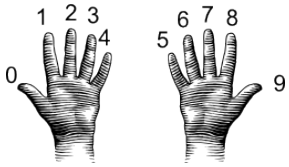

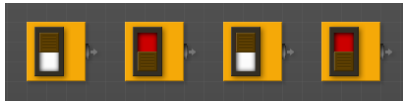

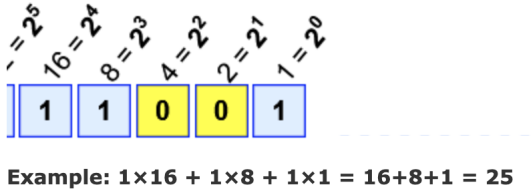

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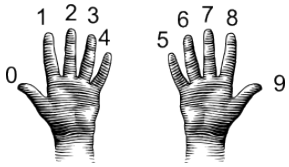

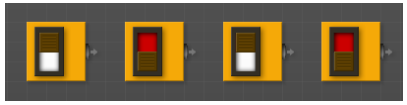

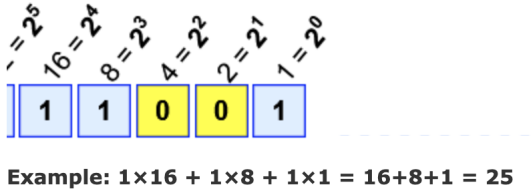

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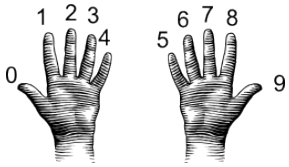

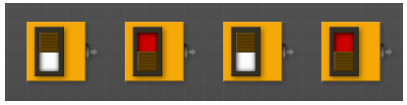

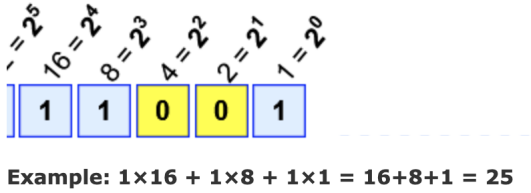

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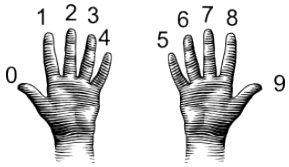

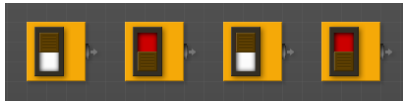

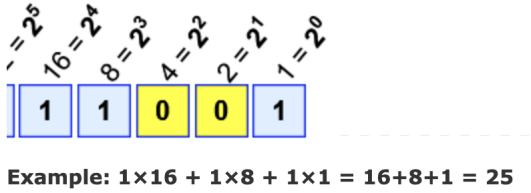

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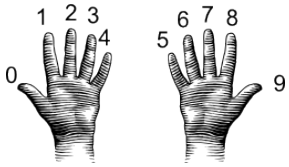

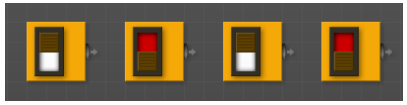

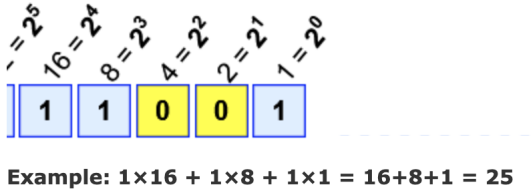

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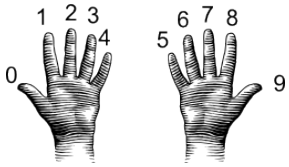

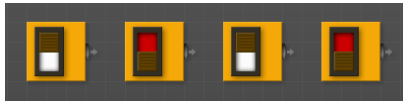

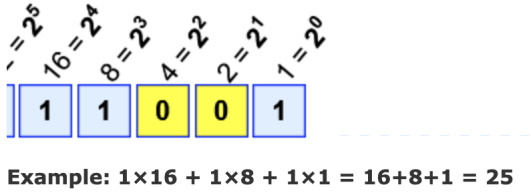

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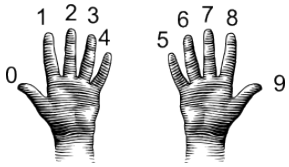

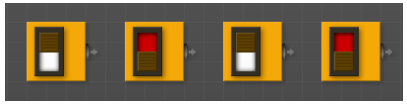

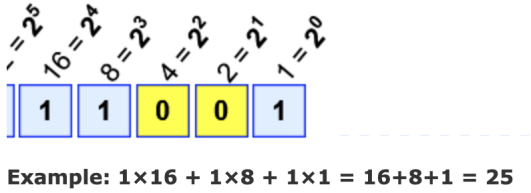

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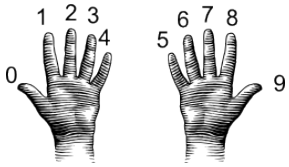

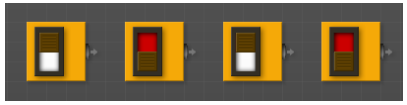

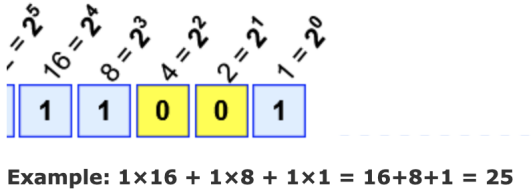

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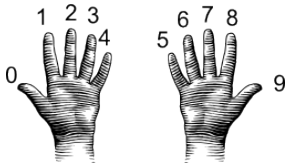

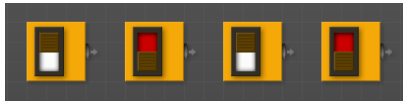

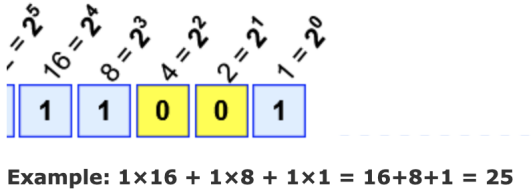

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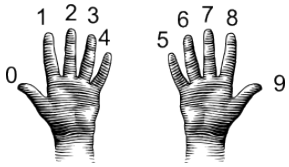

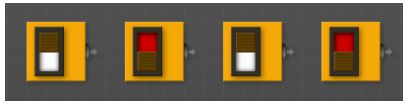

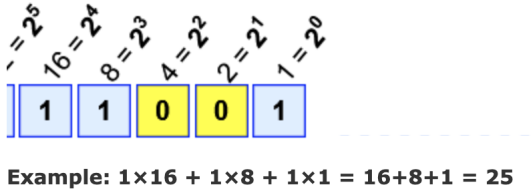

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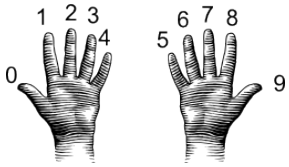

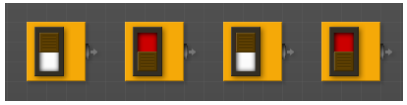

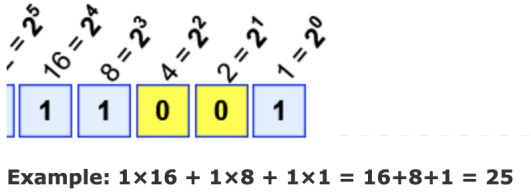

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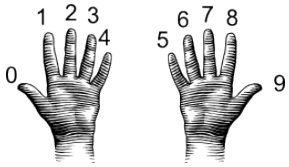

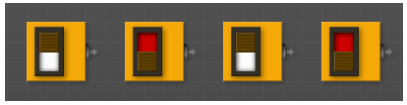

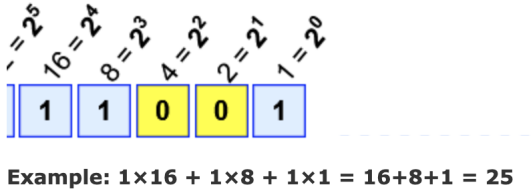

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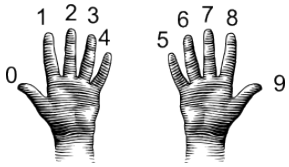

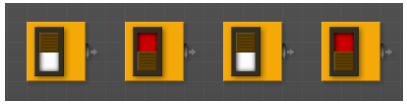

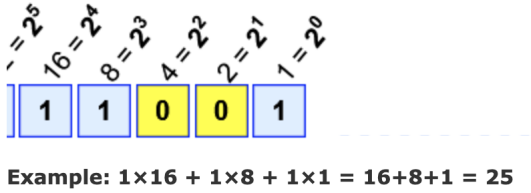

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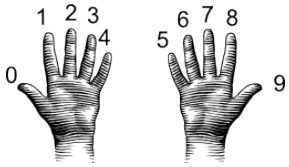

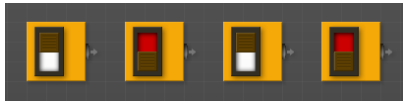

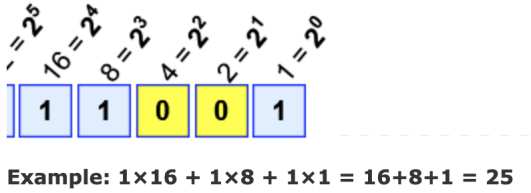

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2/64 is 0 rem 2. Next digit is 0:        10...
2/32 is 0 rem 2. Next digit is 0:        100...
2/16 is 0 rem 2. Next digit is 0:        1000...
2/8 is 0 rem 2. Next digit is 0:         10000...
2/4 is 0 remainder 2. Next digit is 0:   100000...
2/2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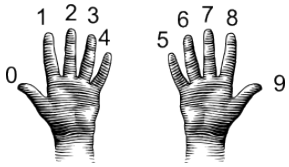
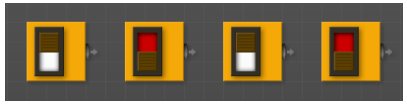
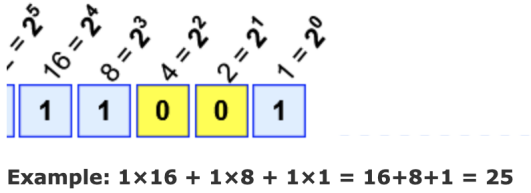

Decimal to Binary: Converting Between Bases



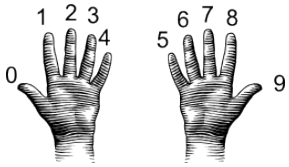


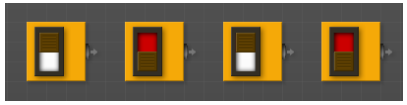


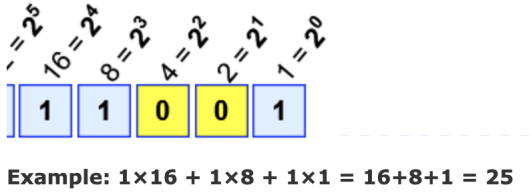
- From decimal to binary:
  - Divide by 128 ($= 2^7$). Quotient is the first digit.
  - Divide remainder by 64 ($= 2^6$). Quotient is the next digit.
  - Divide remainder by 32 ($= 2^5$). Quotient is the next digit.
  - Divide remainder by 16 ($= 2^4$). Quotient is the next digit.
  - Divide remainder by 8 ($= 2^3$). Quotient is the next digit.
  - Divide remainder by 4 ($= 2^2$). Quotient is the next digit.
  - 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...
2/2 is 1 rem 0. Next digit is 1:         1000001...
```

Decimal to Binary: Converting Between Bases







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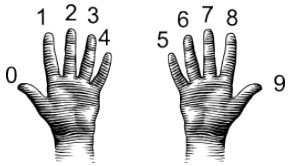
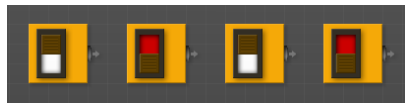
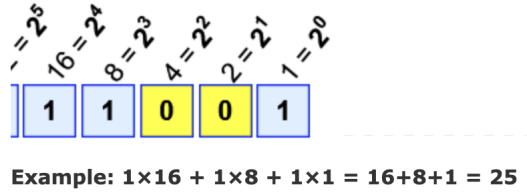
  - Divide remainder by 8 ($= 2^3$). Quotient is the next digit.
  - Divide remainder by 4 ($= 2^2$). Quotient is the next digit.
  - Divide remainder by 2 ($= 2^1$). Quotient is the next digit.
  - The last remainder is the last digit.
  - Example: what is 130 in binary notation?

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

Decimal to Binary: Converting Between Bases







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  - Divide remainder by 4 ($= 2^2$). Quotient is the next digit.
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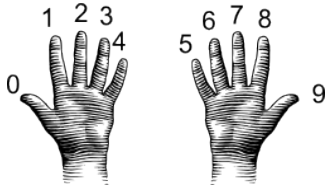
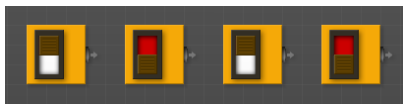
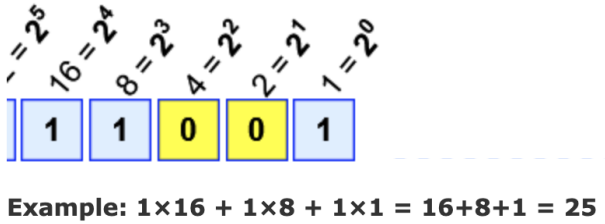
  - Example: what is 130 in binary notation?

```
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...
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
```

Decimal to Binary: Converting Between Bases

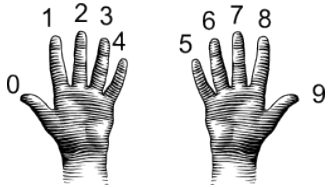


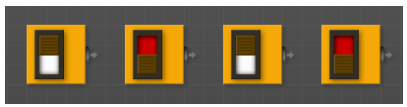


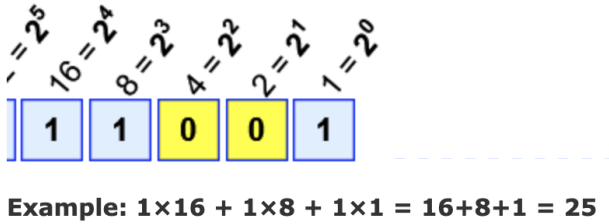


- Example: what is 99 in binary notation?

Decimal to Binary: Converting Between Bases



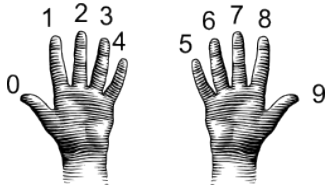


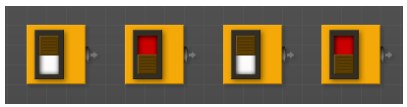


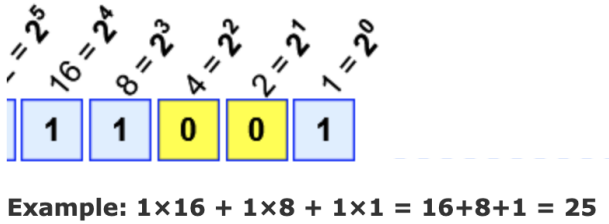
- Example: what is 99 in binary notation?

  `99/128 is 0 rem 99.`

Decimal to Binary: Converting Between Bases



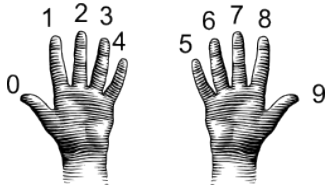


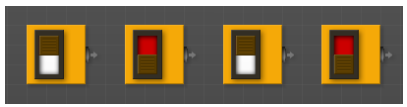


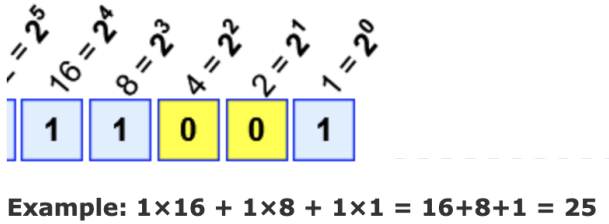
- Example: what is 99 in binary notation?

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

Decimal to Binary: Converting Between Bases





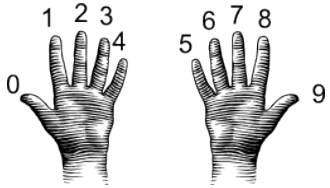


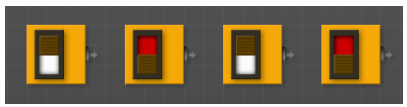
- Example: what is 99 in binary notation?

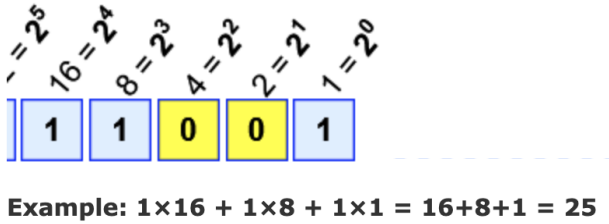
  `99/128 is 0 rem 99. First digit is 0:` 0...

  `99/64 is 1 rem 35.`

Decimal to Binary: Converting Between Bases





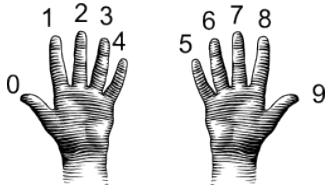


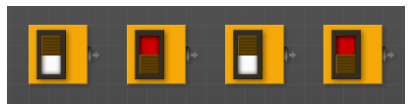
- Example: what is 99 in binary notation?

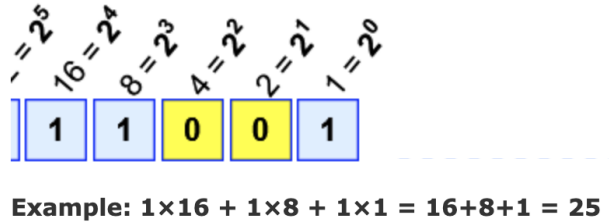
  `99/128 is 0 rem 99. First digit is 0:` 0...

  `99/64 is 1 rem 35. Next digit is 1:`

Decimal to Binary: Converting Between Bases



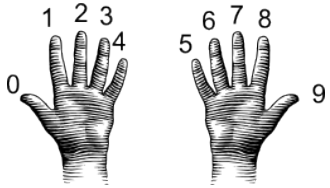


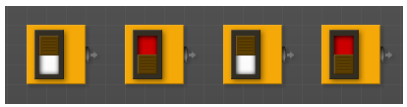


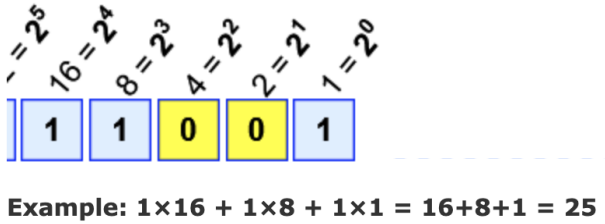
- Example: what is 99 in binary notation?

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

Decimal to Binary: Converting Between Bases



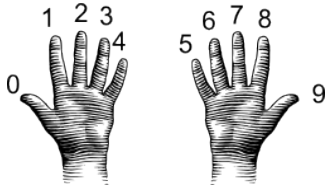


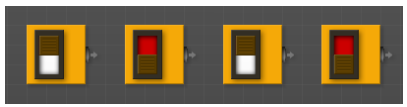


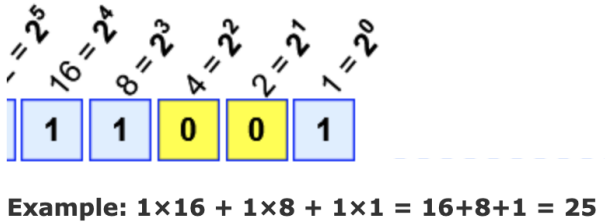
- Example: what is 99 in binary notation?

```
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.
```

Decimal to Binary: Converting Between Bases



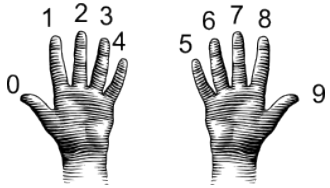


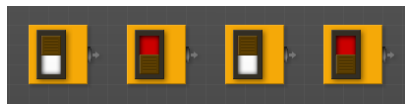


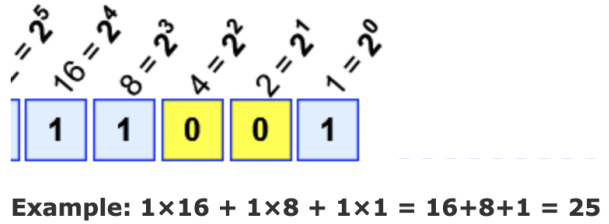
- Example: what is 99 in binary notation?

```
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:
```

Decimal to Binary: Converting Between Bases



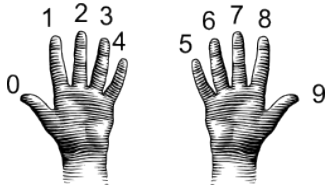


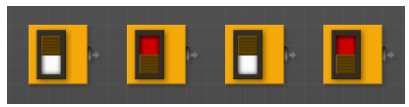


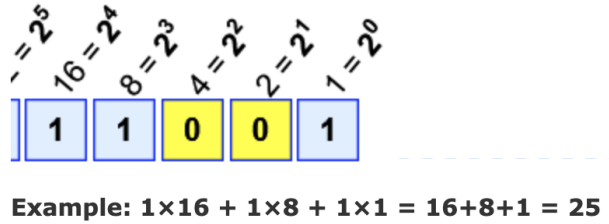
- Example: what is 99 in binary notation?

```
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...
```

Decimal to Binary: Converting Between Bases



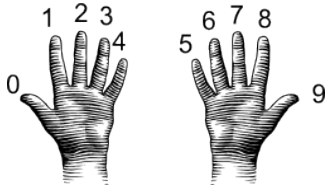


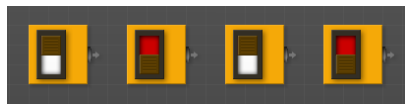


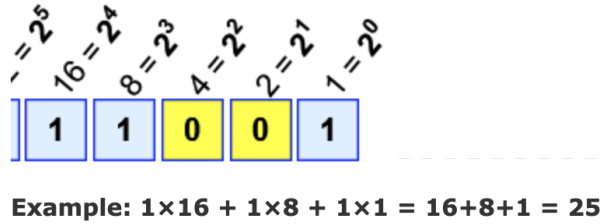
- Example: what is 99 in binary notation?

```
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.
```

Decimal to Binary: Converting Between Bases







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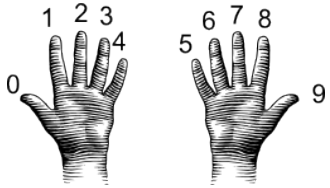
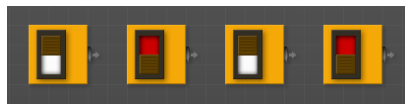
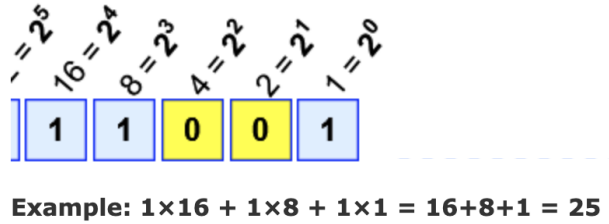
```
99/128 is 0 rem 99. First digit is 0:     0...
99/64 is 1 rem 35. Next digit is 1:       01...
35/32 is 1 rem 3. Next digit is 1:        011...
3/16 is 0 rem 3. Next digit is 0:
```

Decimal to Binary: Converting Between Bases







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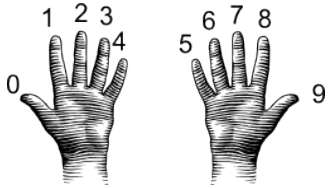

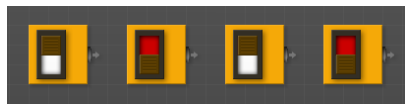

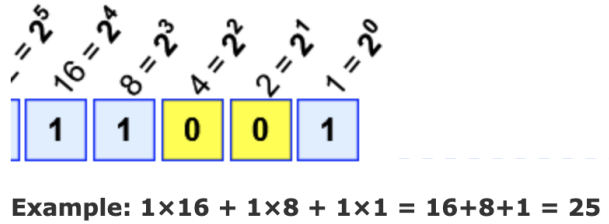

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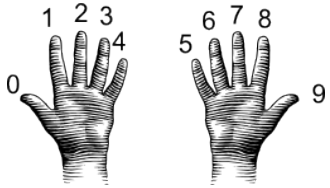

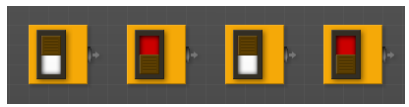

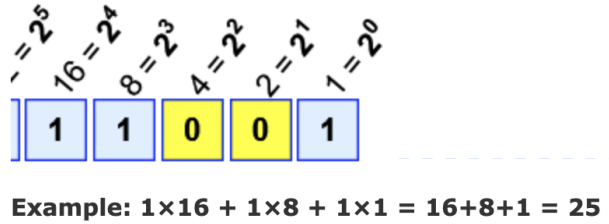

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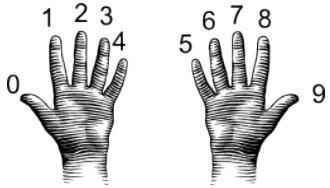

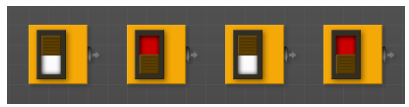

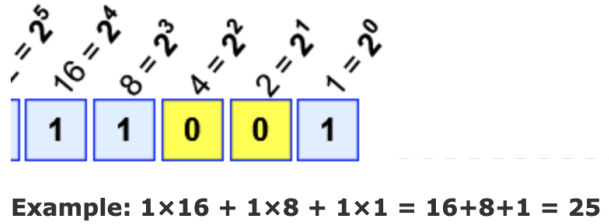

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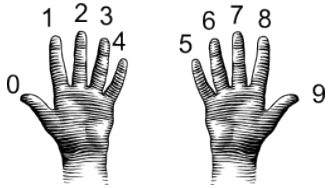

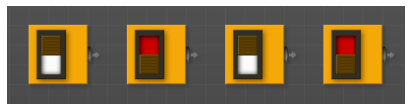

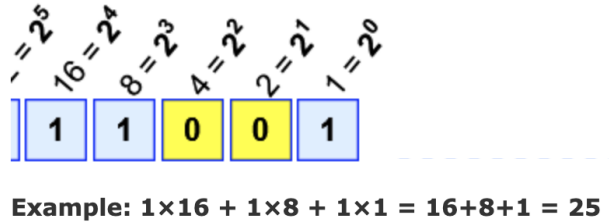

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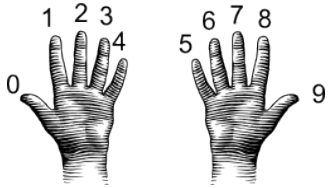
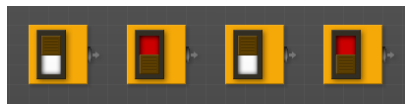
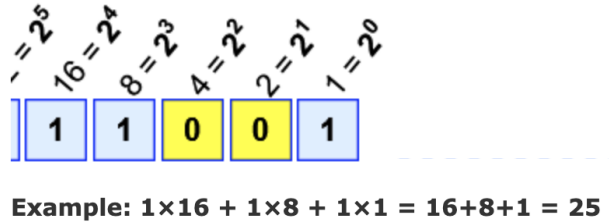
Decimal to Binary: Converting Between Bases







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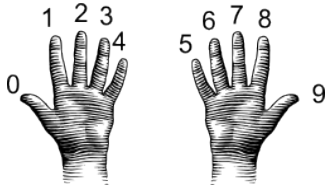

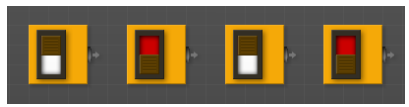

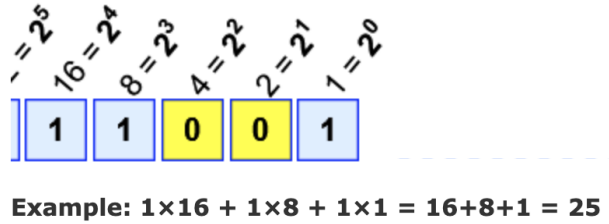

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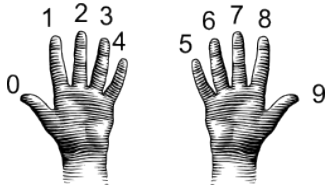

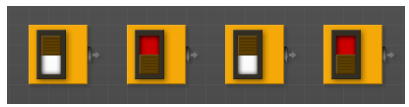

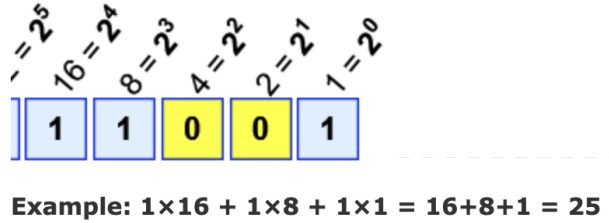

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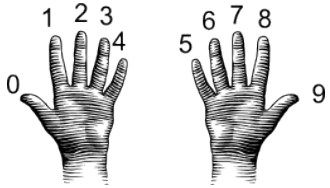

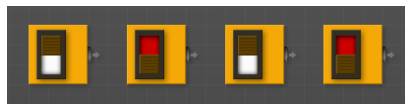

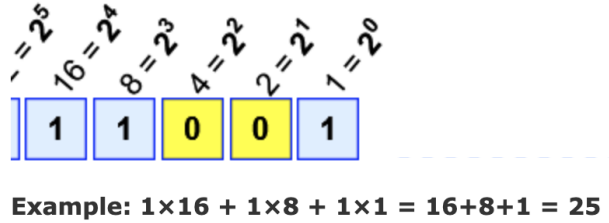

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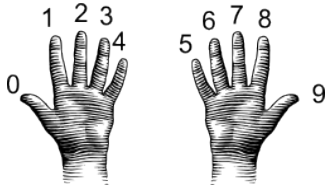

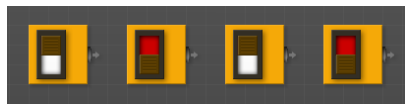

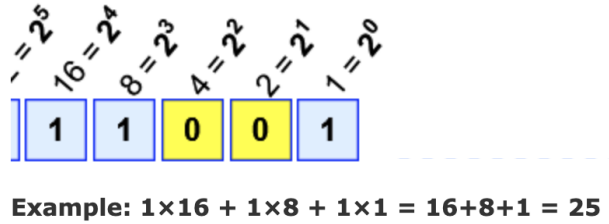

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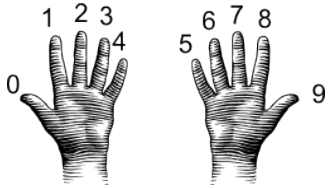

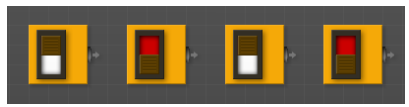

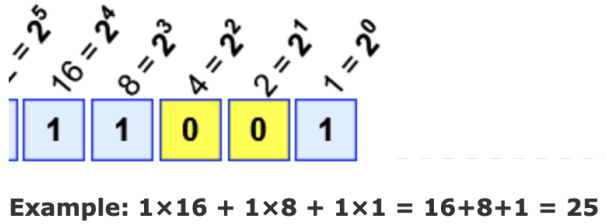

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Adding the last remainder:                01100011
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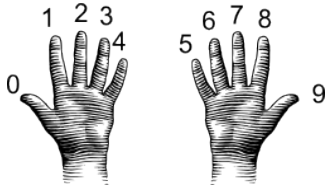
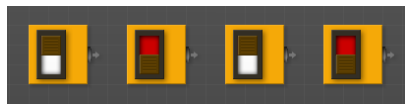
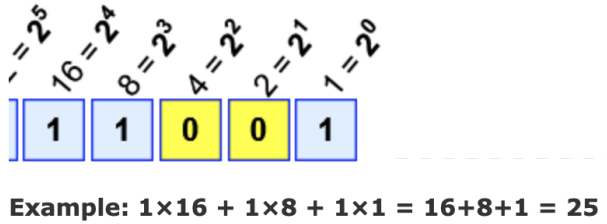
Decimal to Binary: Converting Between Bases







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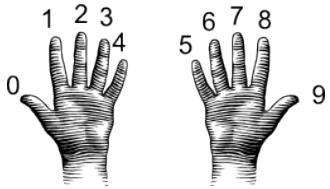
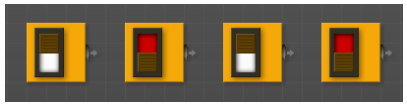
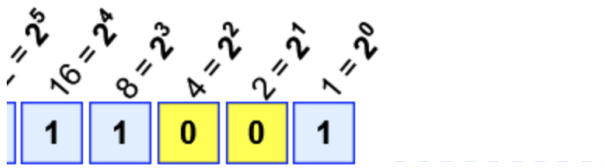
Adding the last remainder:                01100011
```

Answer is 1100011.

Binary to Decimal: Converting Between Bases



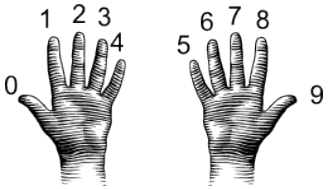


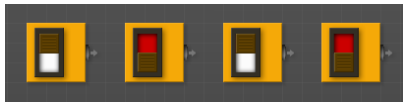


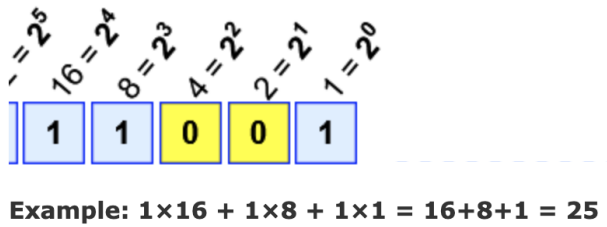
Example: 1×16 + 1×8 + 1×1 = 16+8+1 = 25

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

Binary to Decimal: Converting Between Bases

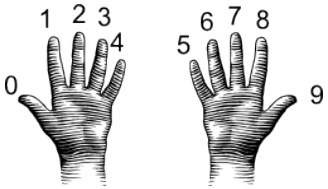


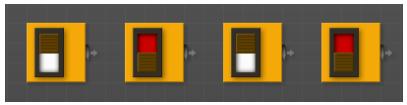


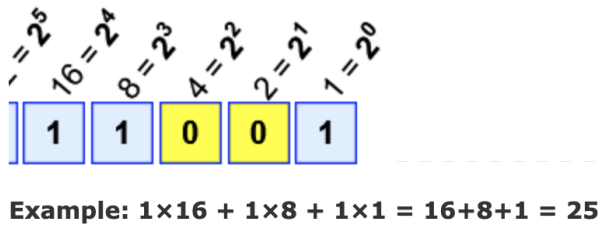


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.

Binary to Decimal: Converting Between Bases

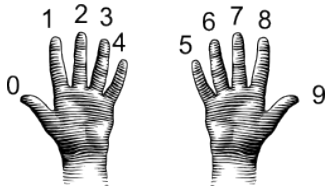


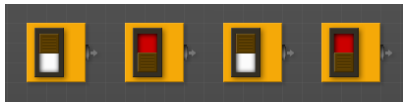


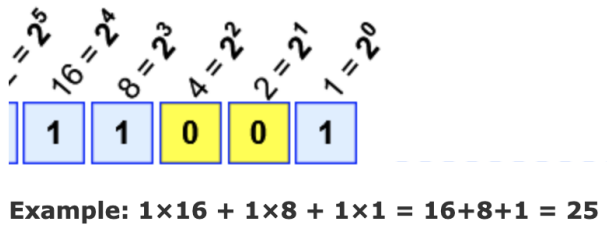


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.

Binary to Decimal: Converting Between Bases

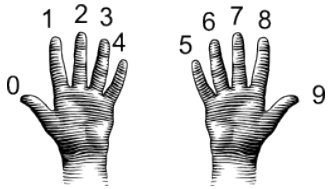


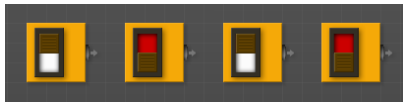


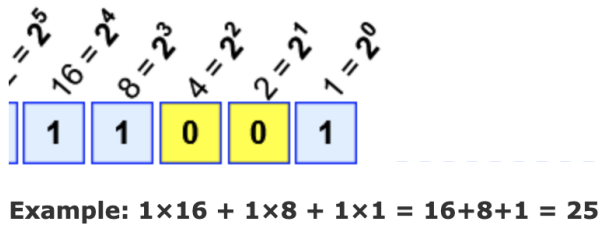


- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.

Binary to Decimal: Converting Between Bases







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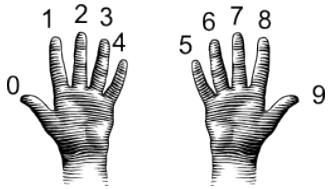
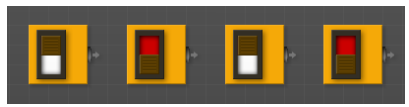
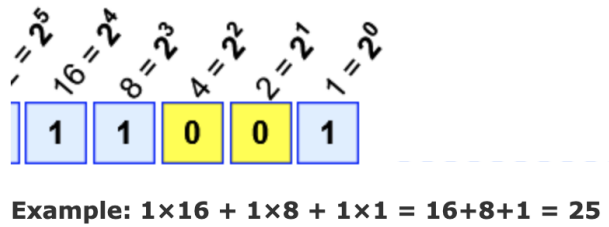
  - Multiply next digit by $16 = 2^4$. Add to sum.

Binary to Decimal: Converting Between Bases







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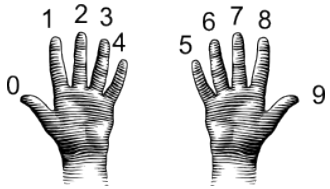
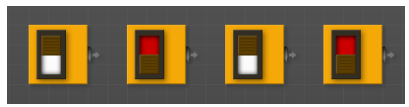
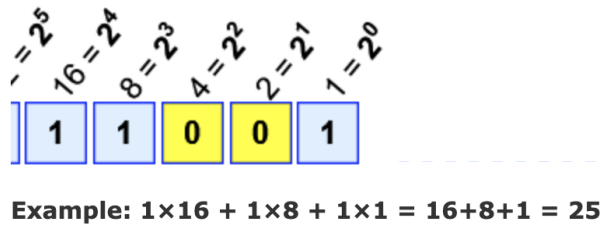
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.

Binary to Decimal: Converting Between Bases







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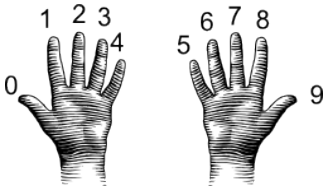
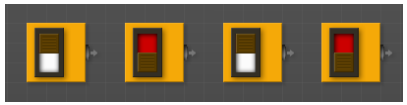
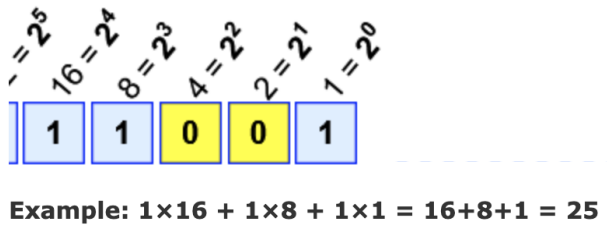
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.

Binary to Decimal: Converting Between Bases







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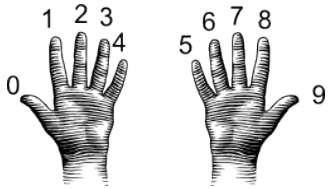
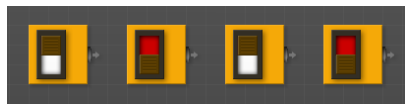
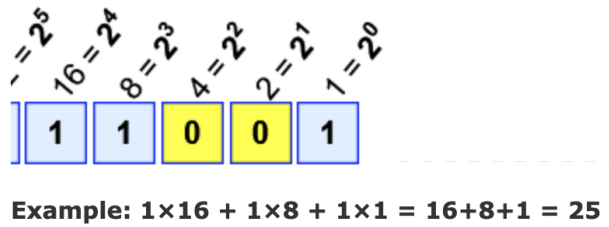
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.

Binary to Decimal: Converting Between Bases







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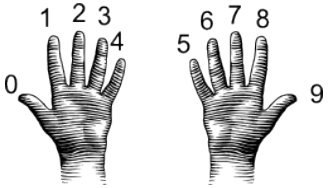
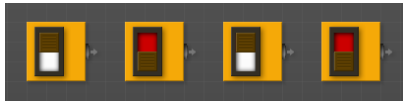
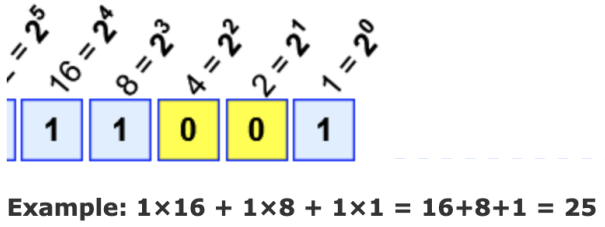
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.

Binary to Decimal: Converting Between Bases







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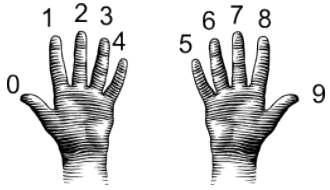
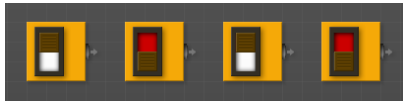
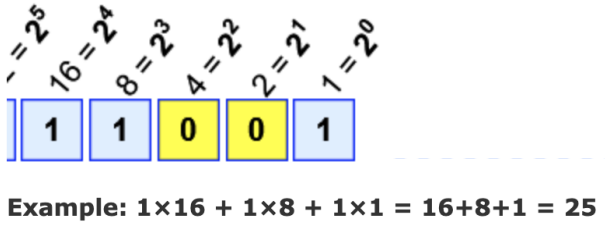
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

    `Sum starts with:`

Binary to Decimal: Converting Between Bases







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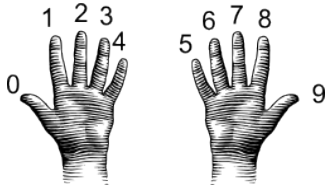
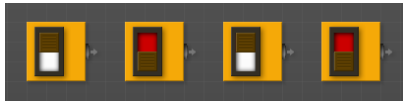
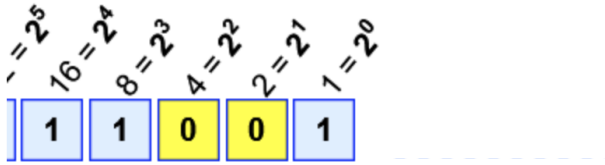
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

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

Binary to Decimal: Converting Between Bases







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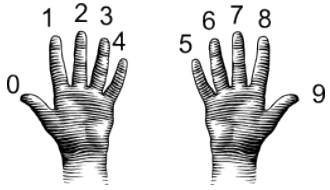
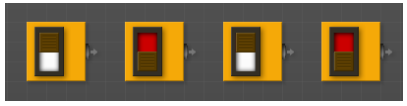
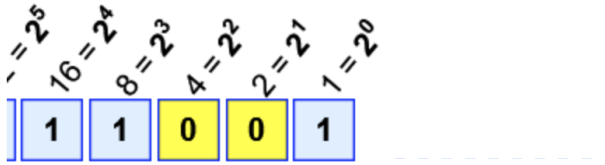
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

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

Binary to Decimal: Converting Between Bases







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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:              1
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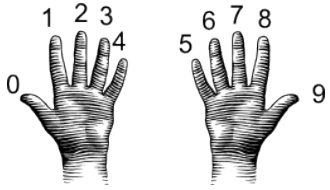
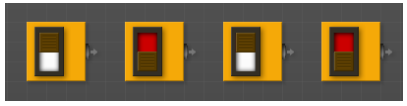
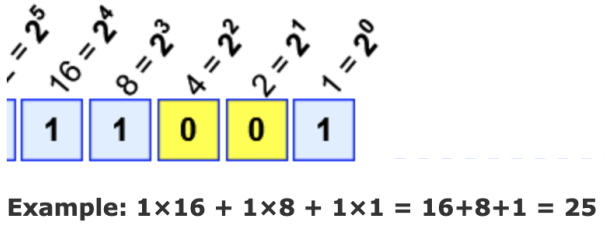
```

Binary to Decimal: Converting Between Bases







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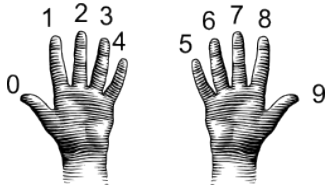
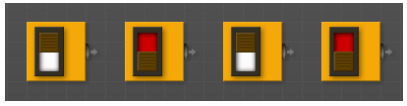
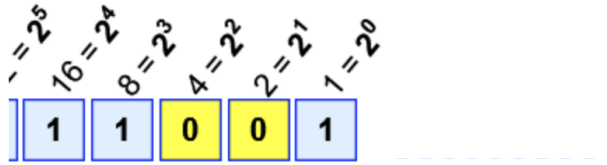
  - Multiply next digit by $32 = 2^5$. Add to sum.
  - Multiply next digit by $64 = 2^6$. Add to sum.
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
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







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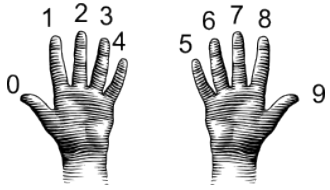
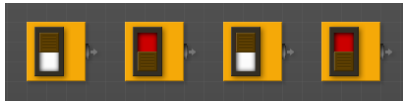
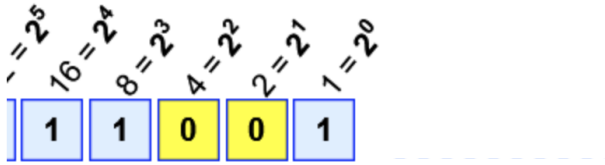
  - Multiply next digit by $128 = 2^7$. Add to sum.
  - Sum is the decimal number.
  - Example: What is 111101 in decimal?

```
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



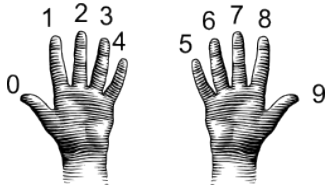


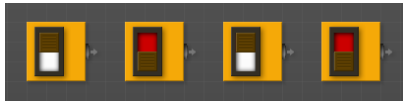


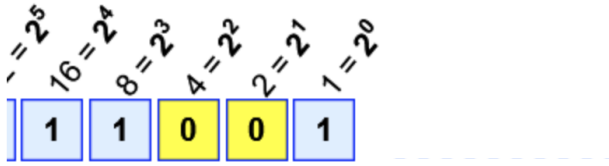
- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
  - Multiply next digit by $4 = 2^2$. Add to sum.
  - Multiply next digit by $8 = 2^3$. Add to sum.
  - Multiply next digit by $16 = 2^4$. Add to sum.
  - Multiply next digit by $32 = 2^5$. Add to sum.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

Binary to Decimal: Converting Between Bases







Example: 1×16 + 1×8 + 1×1 = 16+8+1 = 25

- From binary to decimal:
  - Set sum = last digit.
  - Multiply next digit by $2 = 2^1$. Add to sum.
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  - 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.
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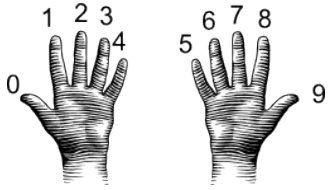
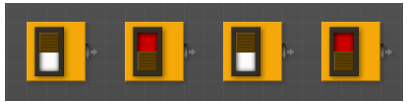
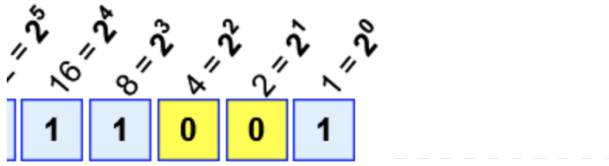
  - Example: What is 111101 in decimal?

```
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







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  - Example: What is 111101 in decimal?

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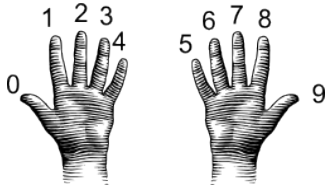
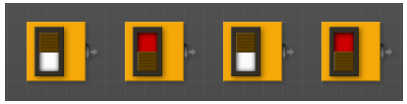
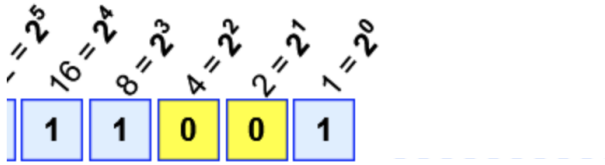
1*8 = 8.  Add 8 to sum:       13
1*16 = 16.  Add 16 to sum:    29
```

Binary to Decimal: Converting Between Bases







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  - Example: What is 111101 in decimal?

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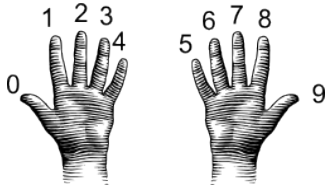
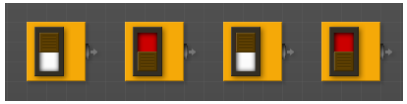
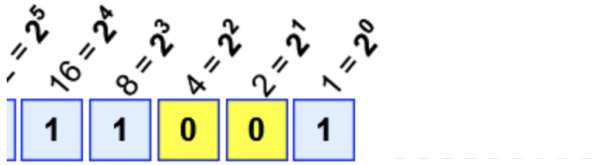
1*16 = 16.  Add 16 to sum:    29
1*32 = 32.  Add 32 to sum:
```

Binary to Decimal: Converting Between Bases







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  - Example: What is 111101 in decimal?

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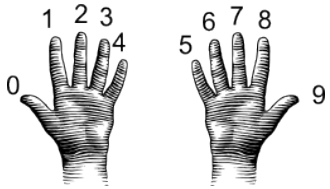
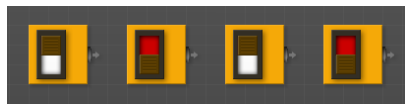
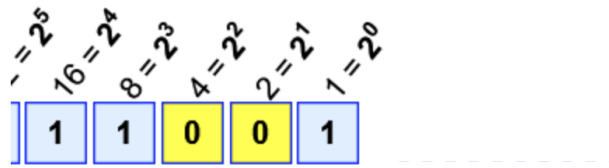
1*4 = 4.  Add 4 to sum:       5
1*8 = 8.  Add 8 to sum:       13
1*16 = 16.  Add 16 to sum:    29
1*32 = 32.  Add 32 to sum:    61
```

Binary to Decimal: Converting Between Bases







Example: 1×16 + 1×8 + 1×1 = 16+8+1 = 25

- From binary to decimal:
  - Set sum = last digit.
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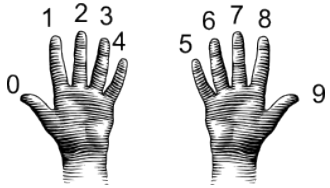
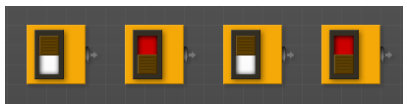
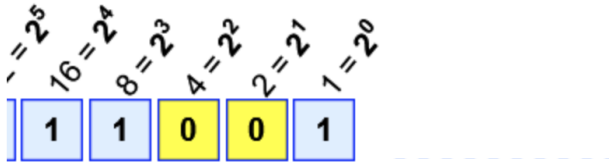
```
Sum starts with:              1
0*2 = 0.  Add 0 to sum:       1
1*4 = 4.  Add 4 to sum:       5
1*8 = 8.  Add 8 to sum:       13
1*16 = 16.  Add 16 to sum:    29
1*32 = 32.  Add 32 to sum:    61
```

Binary to Decimal: Converting Between Bases



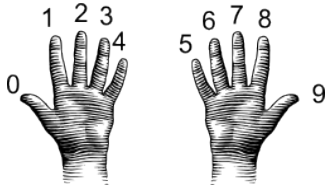


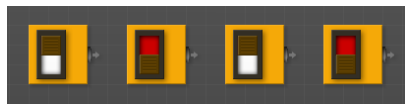


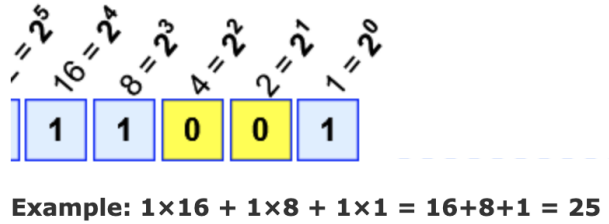
- Example: What is 10100100 in decimal?

  `Sum starts with:`

Binary to Decimal: Converting Between Bases



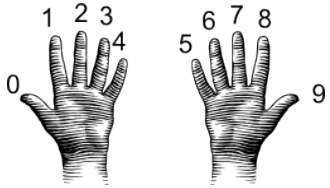


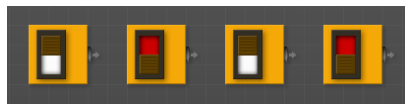


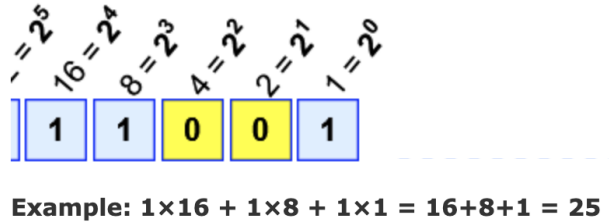
- Example: What is 10100100 in decimal?

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

Binary to Decimal: Converting Between Bases



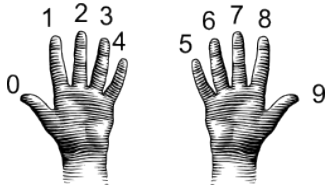


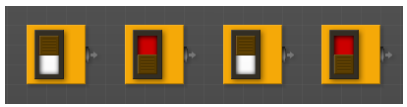


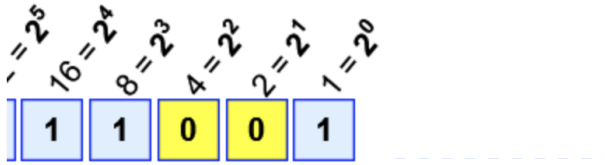
- Example: What is 10100100 in decimal?

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

Binary to Decimal: Converting Between Bases





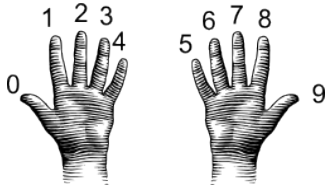


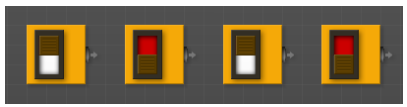
Example: 1×16 + 1×8 + 1×1 = 16+8+1 = 25

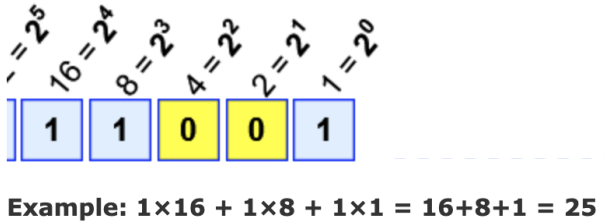
- Example: What is 10100100 in decimal?

```
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
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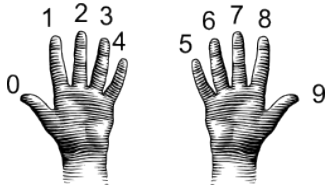
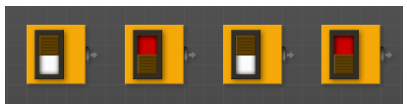
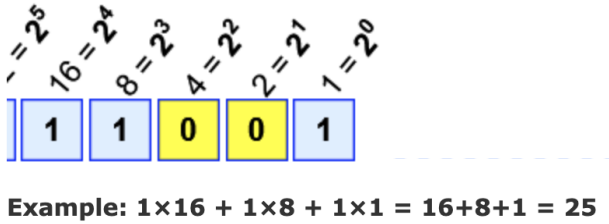
```

Binary to Decimal: Converting Between Bases



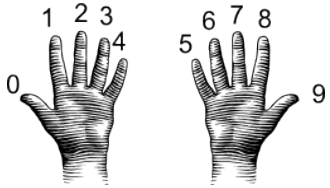


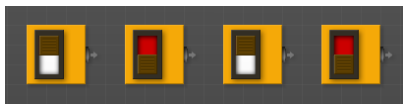


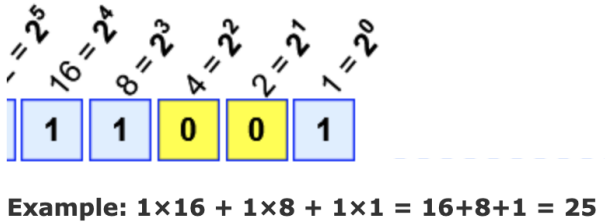
- Example: What is 10100100 in decimal?

```
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







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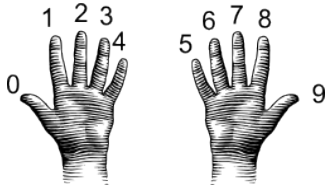
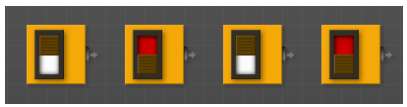
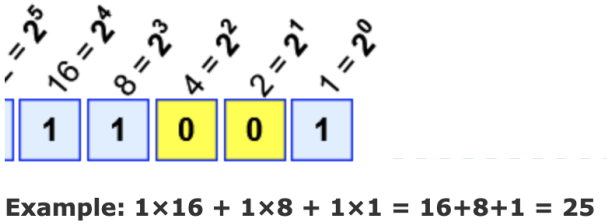
0*8 = 0.  Add 0 to sum:         4
```

Binary to Decimal: Converting Between Bases



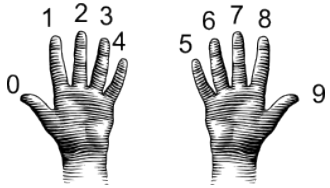


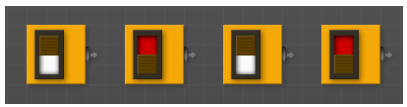


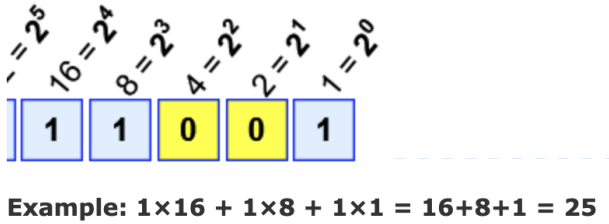
- Example: What is 10100100 in decimal?

```
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







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0*8 = 0.  Add 0 to sum:         4
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```
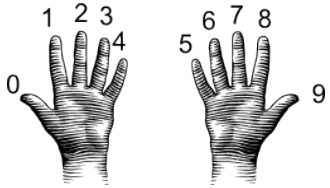
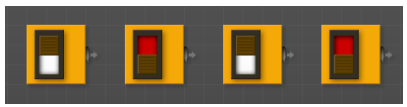
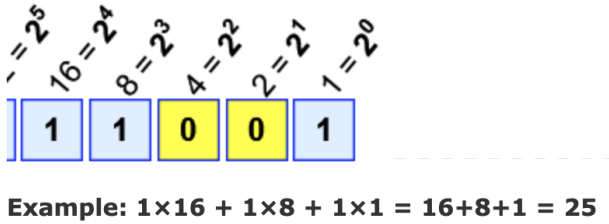

Binary to Decimal: Converting Between Bases







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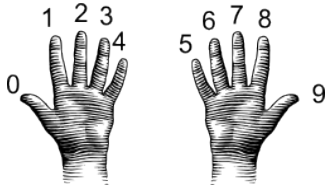
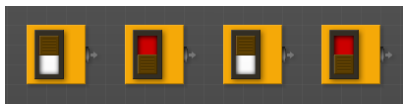
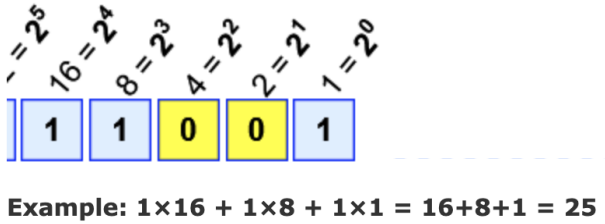
1*4 = 4.  Add 4 to sum:         4
0*8 = 0.  Add 0 to sum:         4
0*16 = 0.  Add 0 to sum:        4
1*32 = 32.  Add 32 to sum:
```

Binary to Decimal: Converting Between Bases







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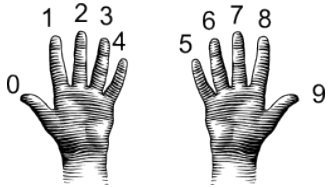
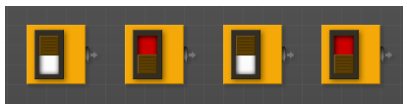
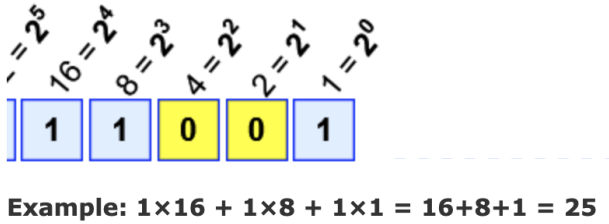
```
Sum starts with:                0
0*2 = 0.  Add 0 to sum:         0
1*4 = 4.  Add 4 to sum:         4
0*8 = 0.  Add 0 to sum:         4
0*16 = 0.  Add 0 to sum:        4
1*32 = 32.  Add 32 to sum:     36
```

Binary to Decimal: Converting Between Bases







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Sum starts with:                0
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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:
```
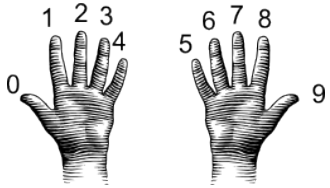
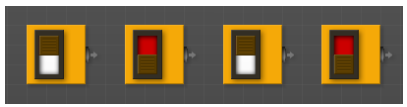
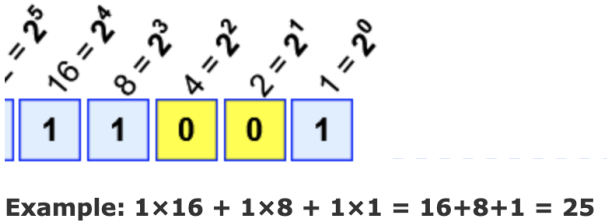

Binary to Decimal: Converting Between Bases







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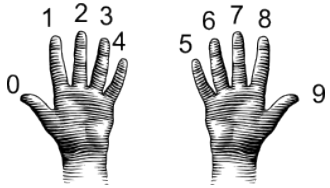
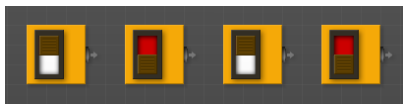
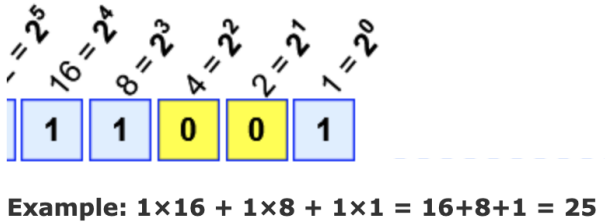
Sum starts with:                0
0*2 = 0.  Add 0 to sum:         0
1*4 = 4.  Add 4 to sum:         4
0*8 = 0.  Add 0 to sum:         4
0*16 = 0.  Add 0 to sum:        4
1*32 = 32.  Add 32 to sum:      36
0*64 = 0.  Add 0 to sum:        36
```

Binary to Decimal: Converting Between Bases







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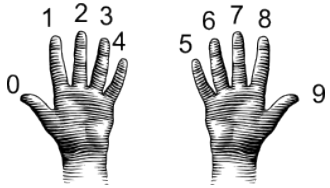
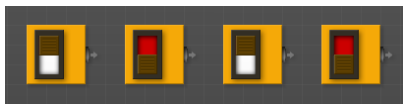
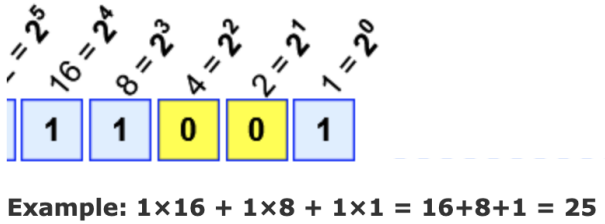
```
Sum starts with:                0
0*2 = 0.  Add 0 to sum:         0
1*4 = 4.  Add 4 to sum:         4
0*8 = 0.  Add 0 to sum:         4
0*16 = 0.  Add 0 to sum:        4
1*32 = 32.  Add 32 to sum:      36
0*64 = 0.  Add 0 to sum:        36
1*128 = 0.  Add 128 to sum:
```

Binary to Decimal: Converting Between Bases







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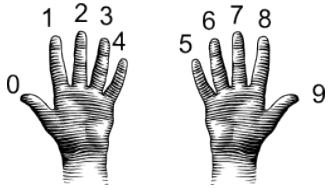
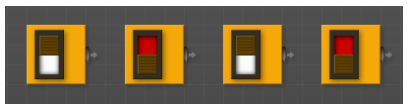
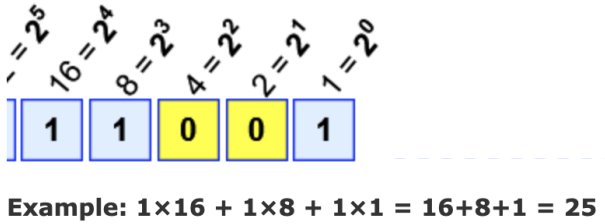
```
Sum starts with:                0
0*2 = 0.  Add 0 to sum:         0
1*4 = 4.  Add 4 to sum:         4
0*8 = 0.  Add 0 to sum:         4
0*16 = 0.  Add 0 to sum:        4
1*32 = 32.  Add 32 to sum:      36
0*64 = 0.  Add 0 to sum:        36
1*128 = 0.  Add 128 to sum:     164
```

Binary to Decimal: Converting Between Bases







- Example: What is 10100100 in decimal?

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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
```
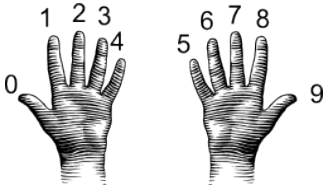
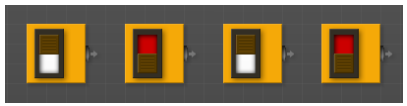
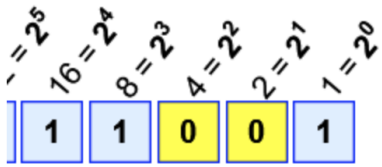

The answer is 164.

Design Challenge: Incrementers



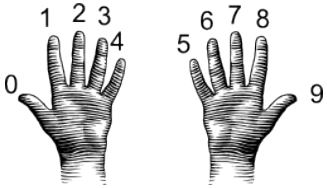


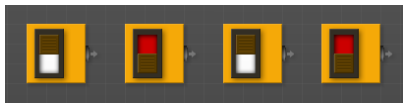


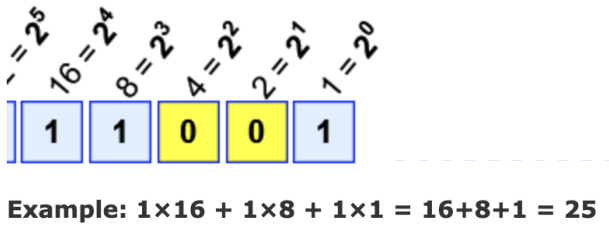
Example: 1×16 + 1×8 + 1×1 = 16+8+1 = 25

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

Design Challenge: Incrementers

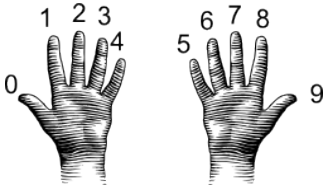


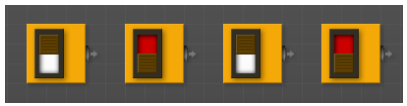


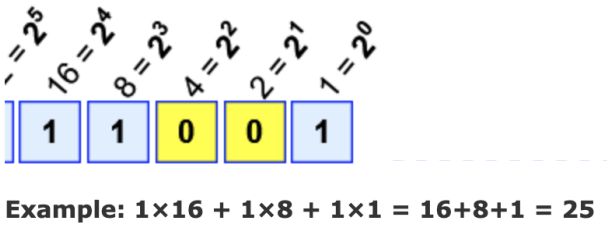


- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

Design Challenge: Incrementers



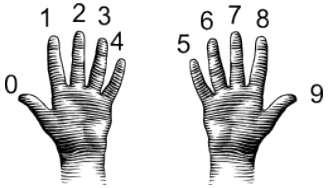


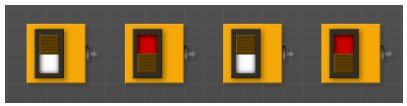


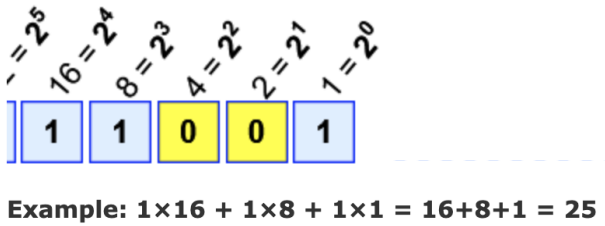
- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

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

Design Challenge: Incrementers





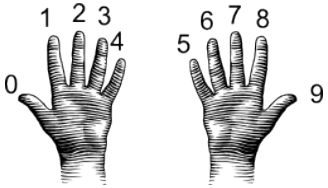


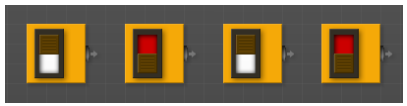
- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

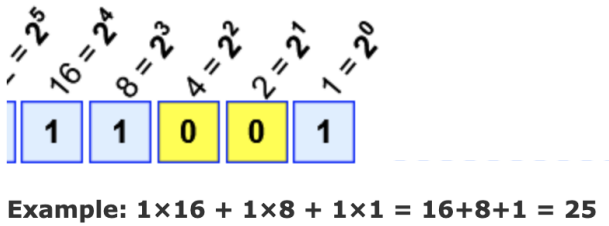
```
def addOne(n):
    m = n+1
    return(m)
```

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

Design Challenge: Incrementers





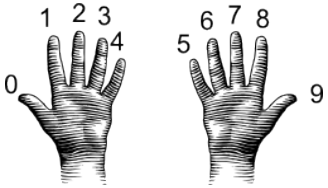


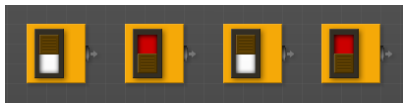
- Simplest arithmetic: add one ("increment") a variable.
- Example: Increment a decimal number:

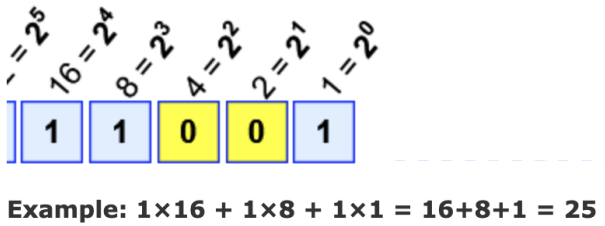
```
def addOne(n):
    m = n+1
    return(m)
```

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

Design Challenge: Incrementers







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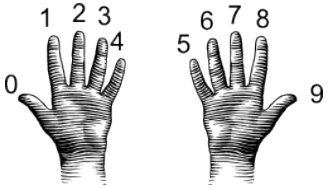
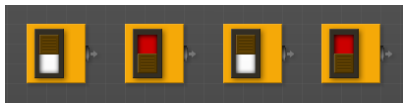
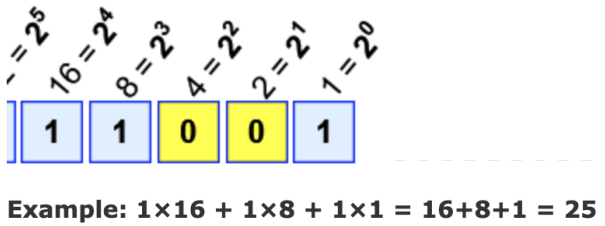
Design Challenge: Incrementers







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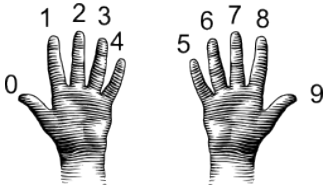

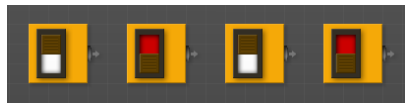

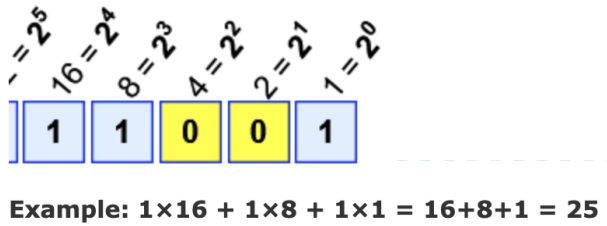

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- Past exams available on webpage (includes answer keys).

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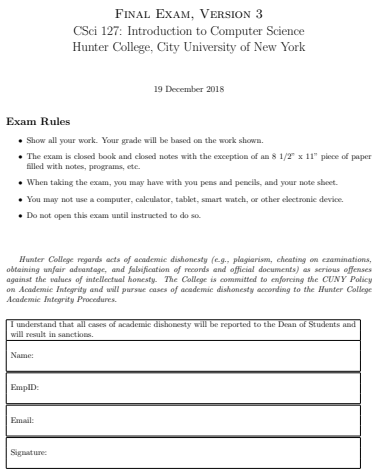

Final Exam, Version 3
CSci 127: Introduction to Computer Science
Hunter College, City University of New York

19 December 2018

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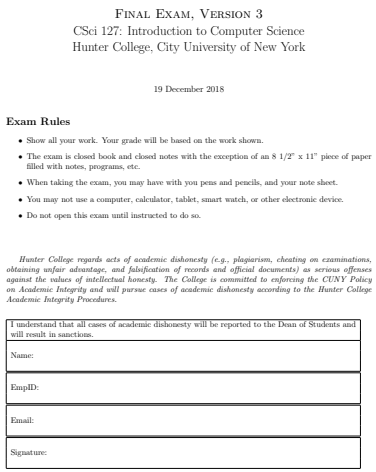

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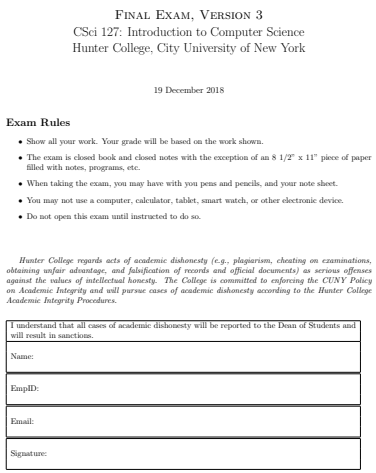

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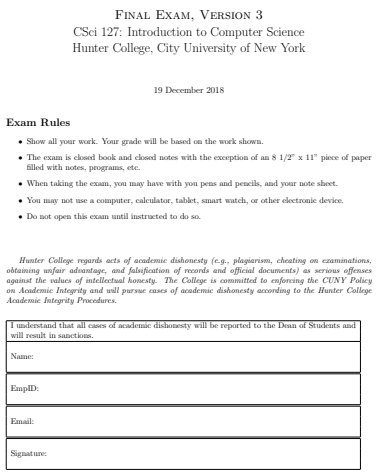

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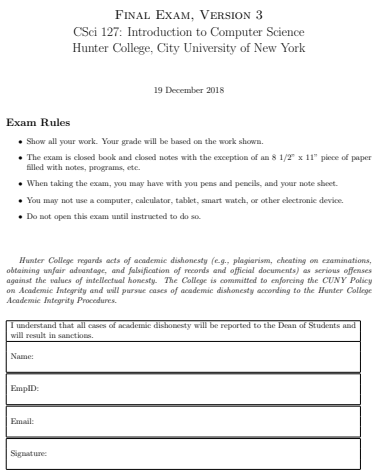

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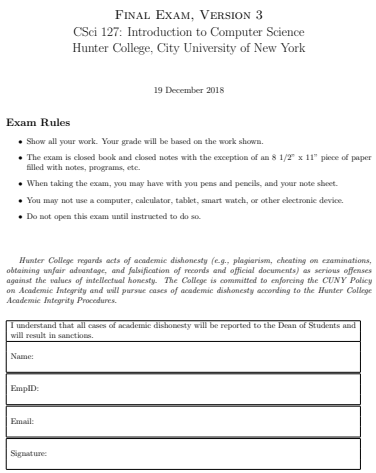

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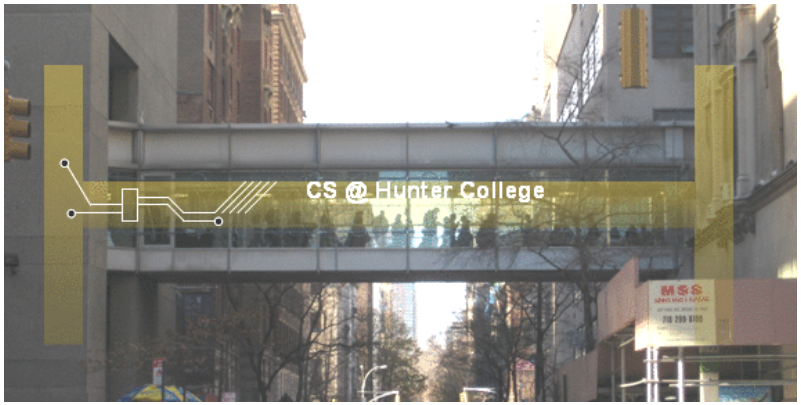

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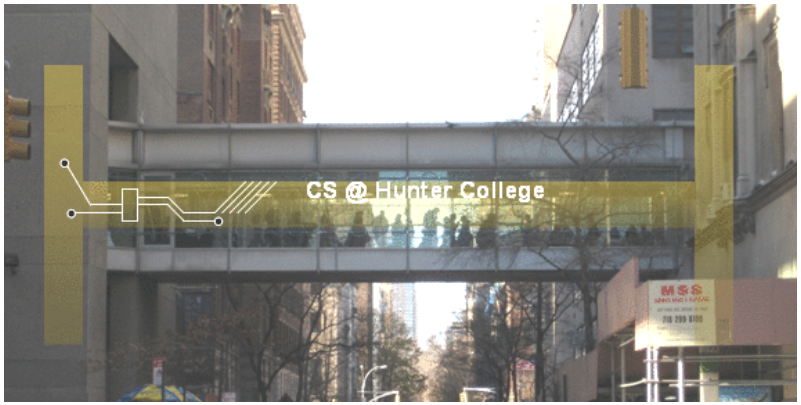

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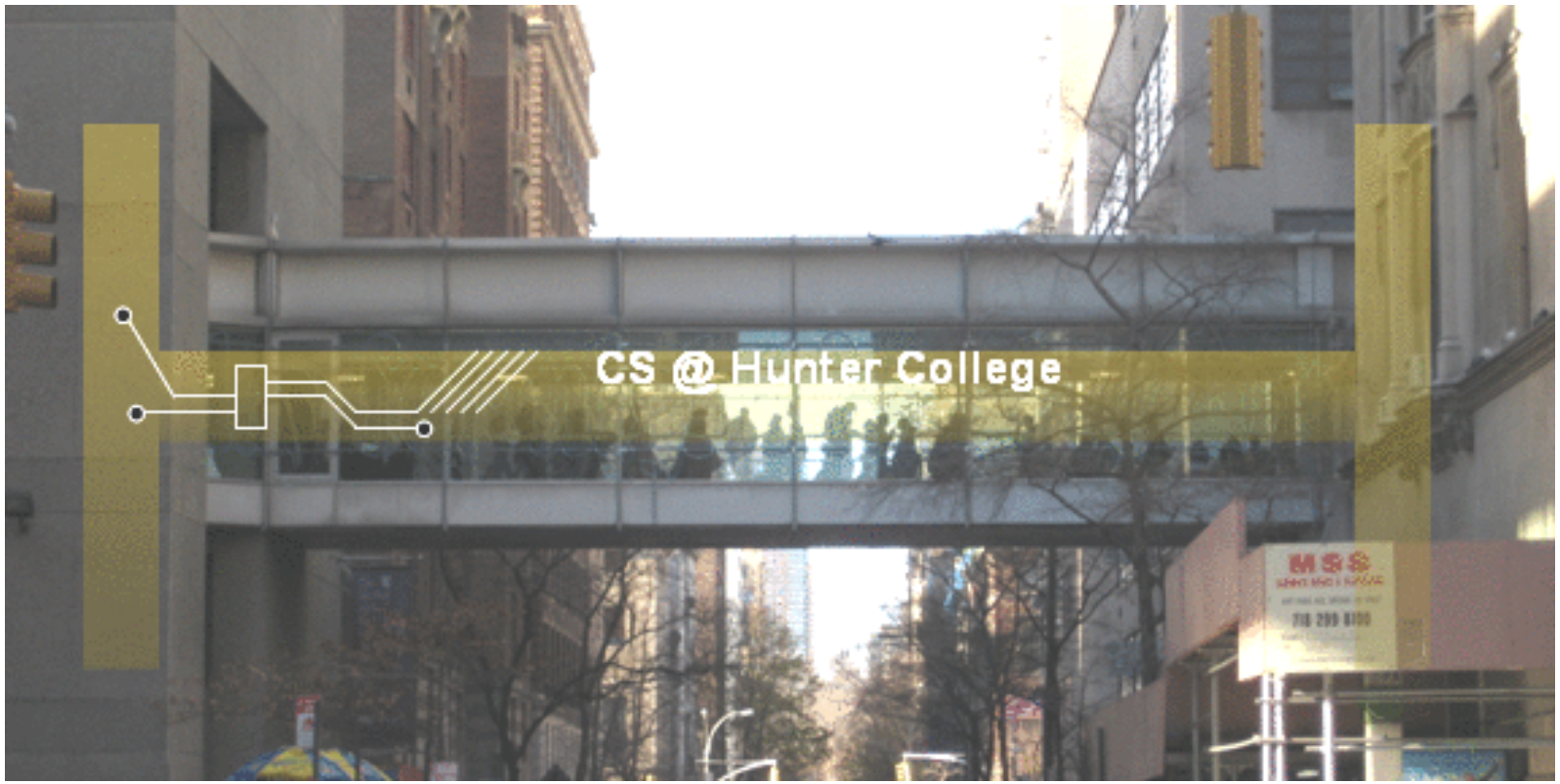
- Take the Lecture Preview on Blackboard on Monday (or no later than 10am on Tuesday)

Lecture Slips & Writing Boards



- Hand your lecture slip to a UTA.
- Return writing boards as you leave.