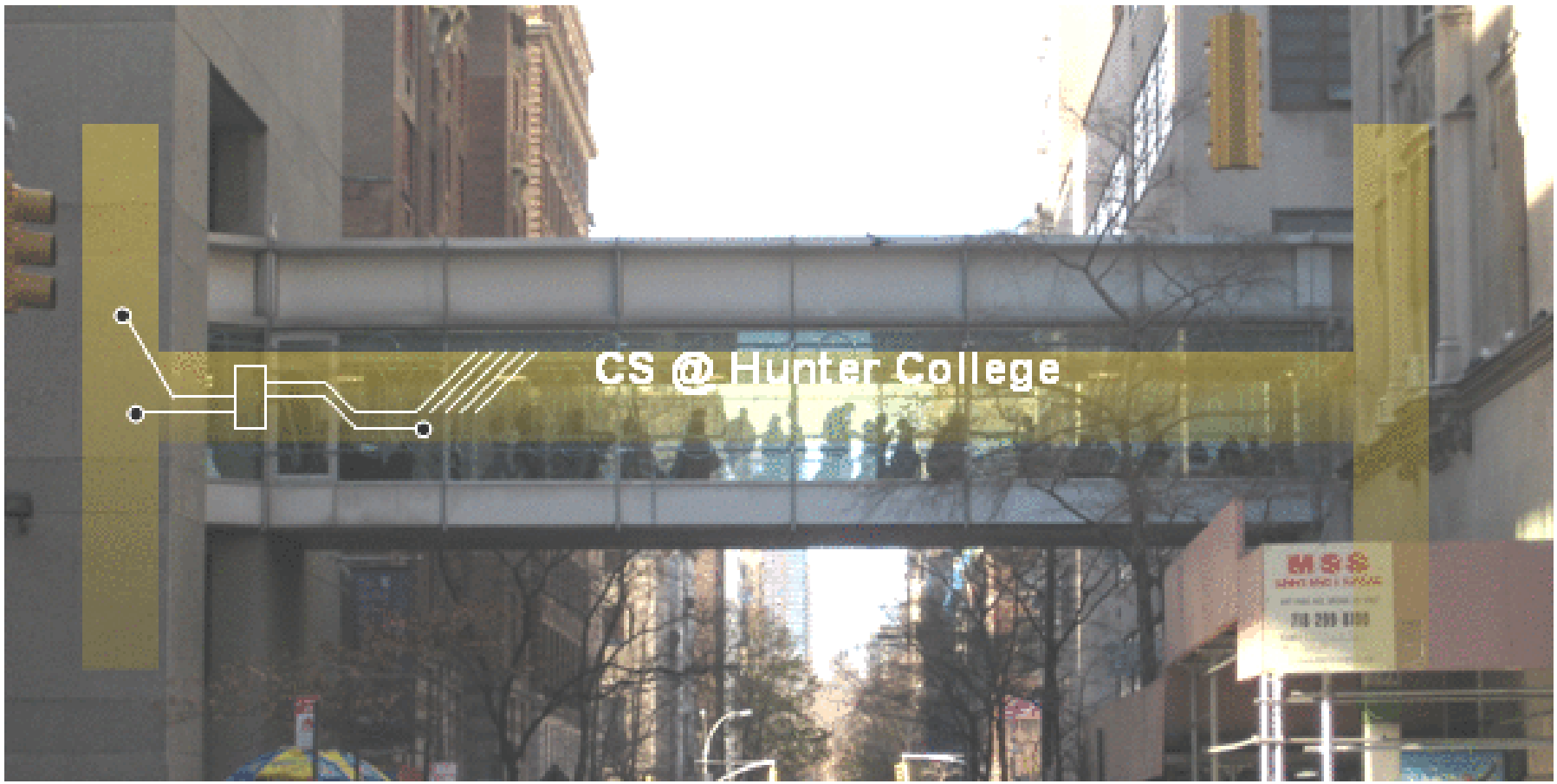
CSci 127: Introduction to Computer Science



hunter.cuny.edu/csci

Announcements

CSci 127 Lab Schedule, Spring 2019				
M	T	W	Th	F
				1/25 L1*
1/28 L1	1/29 L1 Lecture 1	1/30 L1	1/31 L1	2/1 L1
2/4 L2	2/5 L2 Lecture 2	2/6 L2	2/7 L2	2/8 L2
2/11 L3	No class	2/13 L3	2/14 L3	2/15 L3
No class	2/19 L3 Lecture 3	2/20 L4	2/21 L4	2/22 L4
2/25 L4	2/26 L4 Lecture 4	2/27 L5	2/28 L5	3/1 L5
3/4 L5	3/5 L5 Lecture 5	3/6 L6	3/7 L6	3/8 L6
3/11 L6	3/12 L6 Lecture 6	3/13 L7	3/14 L7	3/15 L7
3/18 L7	3/19 L7 Lecture 7	3/20 L8	3/21 L8	3/22 L8
3/25 L8	3/26 L8 Lecture 8	3/27 L9	3/28 L9	3/29 L9
4/1 L9	4/2 L9 Lecture 9	4/3 L10	4/4 L10	4/5 L10
4/8 L10	4/9 L10 Lecture 10	4/10 L11	4/11 L11	4/12 L11
4/15 L11	4/16 L11 Lecture 11	4/17 L12	4/18 L12	No class
No class	No class	No class	No class	No class
4/29 L12	4/30 L12 Lecture 12	5/1 L13	5/2 L13	5/3 L12
5/6 L13	5/7 L13 Lecture 13	5/8 L14	5/9 L14	5/10 L13/L14*
5/13 L14	5/14 L14 Lecture 14	Reading Day		

- Welcome Back!

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- Welcome Back!
- There's no more holidays until April.

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- Guest Lecturer: Katherine Howitt

Frequently Asked Questions

From lecture slips & recitation sections.

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- Could you explain more about arithmetic (especially modulo!) in Python?
  Yes, will do!
- One more time on all the `range()` options?
  We'll have some in group work and a quick review.

Today's Topics

- Arithmetic
- Indexing and Slicing Lists
- Colors & Hexadecimal Notation
- 2D Arrays & Image Files
- Design Challenge: Planes

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Arithmetic

Some arithmetic operators in Python:

- Addition:

Arithmetic

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- Addition: `sum = sum + 3`

Arithmetic

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- Addition: `sum = sum + 3`
- Subtraction:

Arithmetic

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- Addition: `sum = sum + 3`
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Arithmetic

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- Addition: `sum = sum + 3`
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- Multiplication:

Arithmetic

Some arithmetic operators in Python:

- Addition: `sum = sum + 3`
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- Multiplication: `area = h * w`

Arithmetic

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- Division:

Arithmetic

Some arithmetic operators in Python:

- Addition: `sum = sum + 3`
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- Division: `ave = total / n`

Arithmetic

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- Floor or Integer Division:

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  `weeks = totalDays // 7`

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- Remainder or Modulus:

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- Remainder or Modulus:
  `days = totalDays % 7`
- Exponentiaion:
  `pop = 2**time`

In Pairs or Triples...

What does this code do?

```
#Mystery code for lecture 3

startTime = int(input('Enter starting time: '))
duration = int(input('Enter how long: '))

print('Your event starts at', startTime, "o'clock.")

endTime = (startTime+duration)%12
print('Your event ends at', endTime, "o'clock.")
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- If the user enters, 9 and 2.
- If the user enters, 12 and 4.

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- If the user enters, 9 and 2.
- If the user enters, 12 and 4.
- If the user enters, 8 and 20.

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- If the user enters, 12 and 4.
- If the user enters, 8 and 20.
- If the user enters, 11 and 1.

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```
Enter starting time: 9
Enter how long: 2
Your event starts at 9 o'clock.
Your event ends at 11 o'clock.
```

In Pairs or Triples...

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In particular, what is printed...

- If the user enters, 12 and 4.

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Enter starting time: 12
Enter how long: 4
Your event starts at 12 o'clock.
Your event ends at 4 o'clock.
```

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```
Enter starting time: 8
Enter how long: 20
Your event starts at 8 o'clock.
Your event ends at 4 o'clock.
```

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- If the user enters, 11 and 1.

```
Enter starting time: 11
Enter how long: 1
Your event starts at 11 o'clock.
Your event ends at 0 o'clock.
```

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- Colors & Hexadecimal Notation
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In Pairs or Triples...

Mostly review:

```
 1  for d in range(10, 0, -1):
 2      print(d)
 3  print("Blast off!")
 4
 5  for num in range(5,8):
 6      print(num, 2*num)
 7
 8  s = "City University of New York"
 9  print(s[3], s[0:3], s[:3])
10  print(s[5:8], s[-1])
11
12  names = ["Eleanor", "Anna", "Alice", "Edith"]
13  for n in names:
14      print(n)
```

Python Tutor

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12 names = ["Eleanor", "Anna", "Alice", "Edith"]
13 for n in names:
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(Demo with pythonTutor)

Review: range()

The three versions:

Review: range()

The three versions:

- `range(stop)`

Review: range()

The three versions:

- `range(stop)`
- `range(start, stop)`

Review: range()

The three versions:

- `range(stop)`
- `range(start, stop)`
- `range(start, stop, step)`

Slices

- Similar to `range()`, you can take portions or **slices** of lists and strings:

```
1  for d in range(10, 0, -1):
2      print(d)
3  print("Blast off!")
4
5  for num in range(5,8):
6      print(num, 2*num)
7
8  s = "City University of New York"
9  print(s[3], s[0:3], s[:3])
10 print(s[5:8], s[-1])
11
12 names = ["Eleanor", "Anna", "Alice", "Edith"]
13 for n in names:
14     print(n)
```

Slices

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  `s[5:8]`

  gives: `"Uni"`

Slices

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  `s[5:8]`

  gives: `"Uni"`
- Also works for lists:

Slices

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Slices

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  gives: `"Uni"`
- Also works for lists:

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  gives: `["Anna", "Alice"]`

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```

- Similar to `range()`, you can take portions or **slices** of lists and strings:

  `s[5:8]`

  gives: `"Uni"`
- Also works for lists:

  `names[1:3]`

  gives: `["Anna", "Alice"]`
- Python also lets you "count backwards": last element has index: `-1`.

Today's Topics

- Arithmetic
- Indexing and Slicing Lists
- **Colors & Hexadecimal Notation**
- 2D Arrays & Image Files
- Design Challenge: Planes

Colors

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

- Can specify by name.

Colors

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- Can specify by numbers:
  - Amount of Red, Green, and Blue (RGB).

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  - Adding light, not paint:

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- Can specify by name.
- Can specify by numbers:
  - Amount of Red, Green, and Blue (RGB).
  - Adding light, not paint:
    - ★ Black: 0% red, 0% green, 0% blue

Colors

Color Name	HEX	Color
Black	#000000	
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- Can specify by name.
- Can specify by numbers:
  - Amount of Red, Green, and Blue (RGB).
  - Adding light, not paint:
    - ★ Black: 0% red, 0% green, 0% blue
    - ★ White: 100% red, 100% green, 100% blue

Colors

Color Name	HEX	Color
Black	#000000	
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MediumBlue	#0000CD	
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- Can specify by numbers (RGB):

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- Can specify by numbers (RGB):
  - Fractions of each:

Colors

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- Can specify by numbers (RGB):
  - Fractions of each:
    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.

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- Can specify by numbers (RGB):
  - Fractions of each:
    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.
  - 8-bit colors: numbers from 0 to 255:

Colors

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- Can specify by numbers (RGB):
  - Fractions of each:
    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.
  - 8-bit colors: numbers from 0 to 255:
    e.g. `(0, 255, 0)` is no red, 100% green, and no blue.

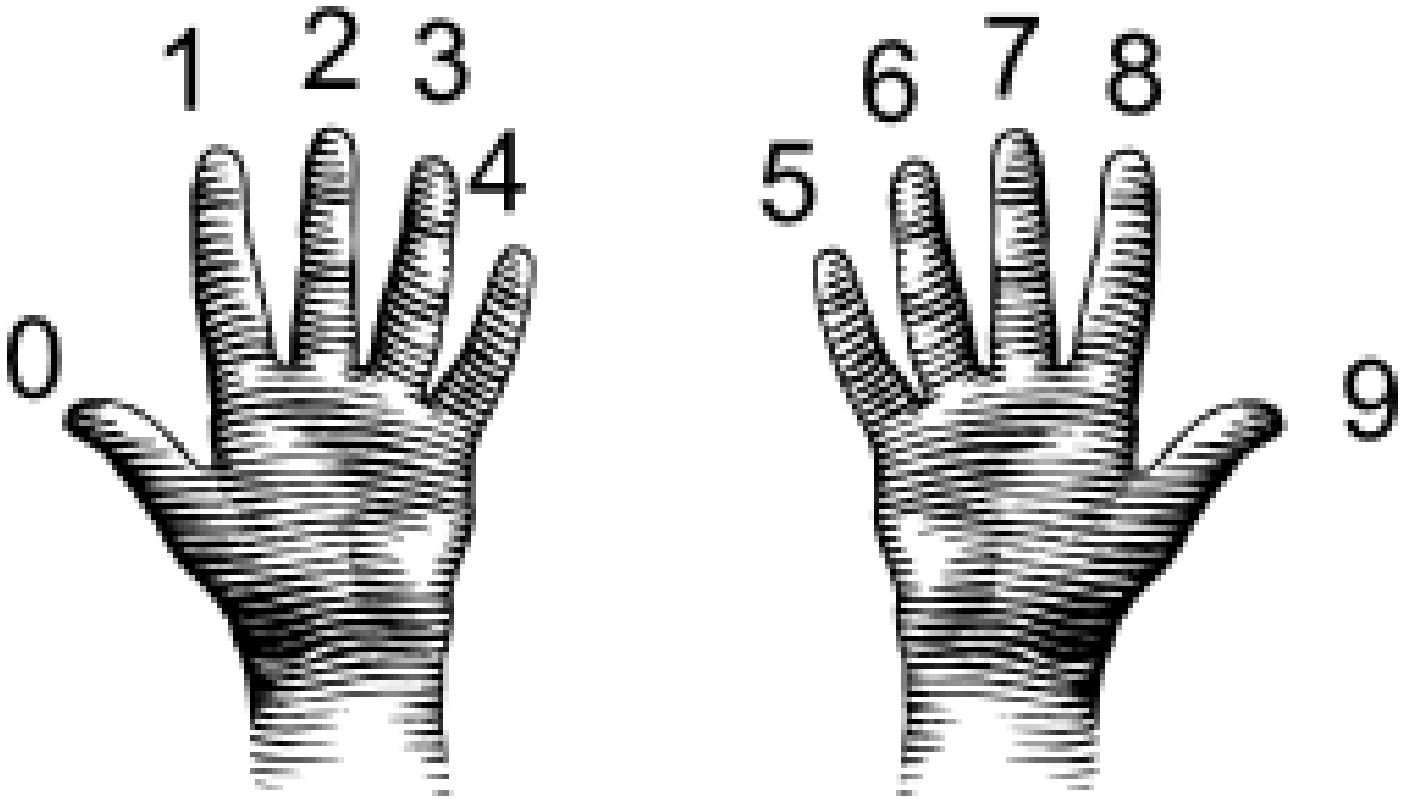
Colors

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

- Can specify by numbers (RGB):
  - Fractions of each:
    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.
  - 8-bit colors: numbers from 0 to 255:
    e.g. `(0, 255, 0)` is no red, 100% green, and no blue.
  - Hexcodes (base-16 numbers)...

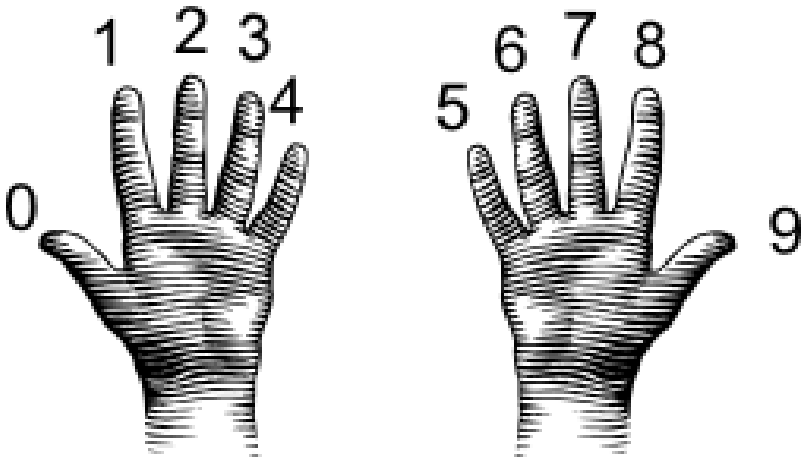
Decimal & Hexadecimal Numbers

Counting with 10 digits:



(from i-programmer.info)

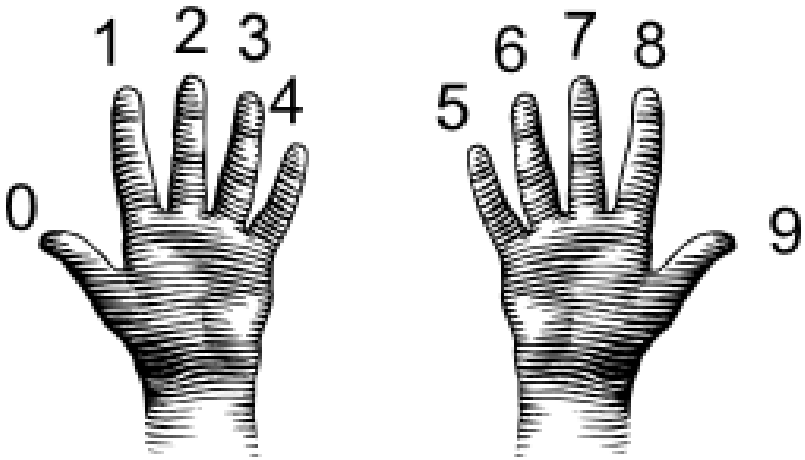
Decimal



(from i-programmer.info)

Decimal

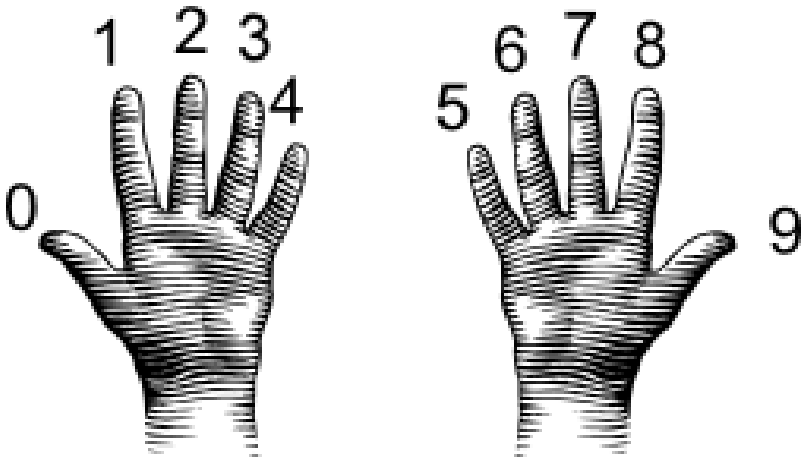
00 01 02 03 04 05 06 07 08 09



(from i-programmer.info)

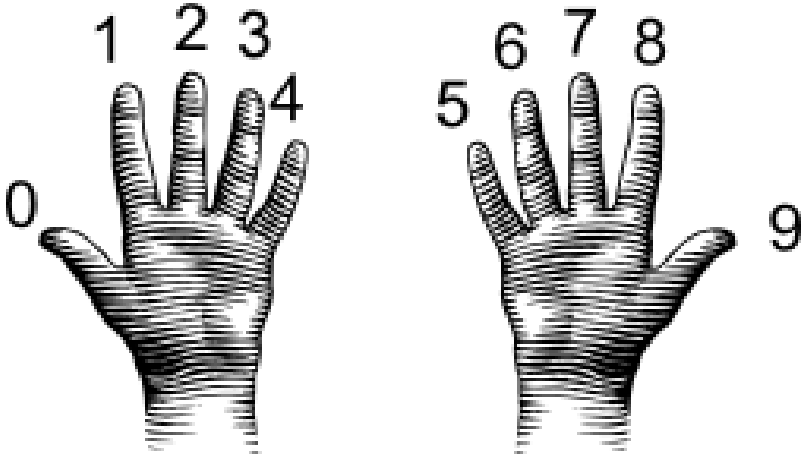
Decimal

00 01 02 03 04 05 06 07 08 09
10 11 12 13 14 15 16 17 18 19



(from i-programmer.info)

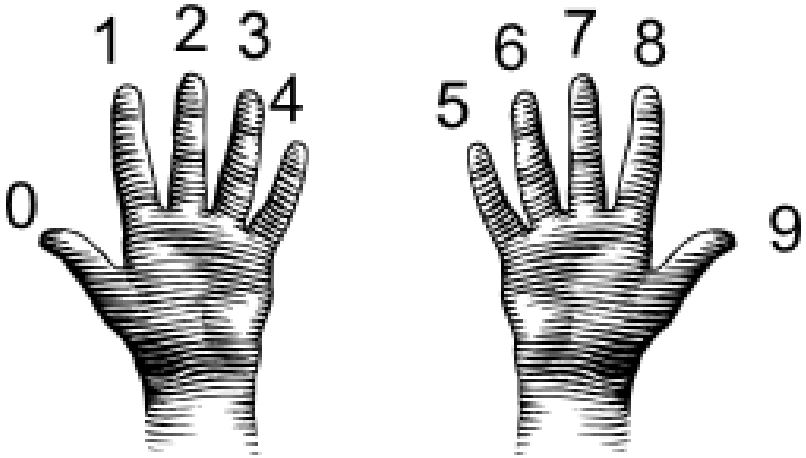
Decimal



(from i-programmer.info)

00 01 02 03 04 05 06 07 08 09
10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29

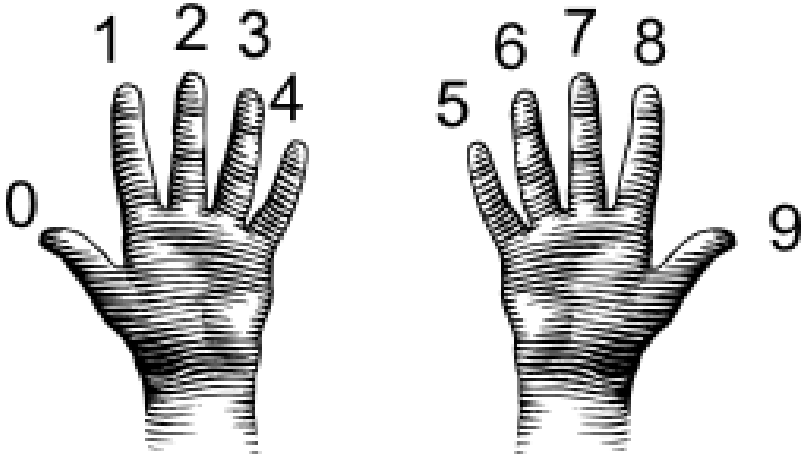
Decimal



(from i-programmer.info)

00 01 02 03 04 05 06 07 08 09
10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29
30 31 32 33 34 35 36 37 38 39

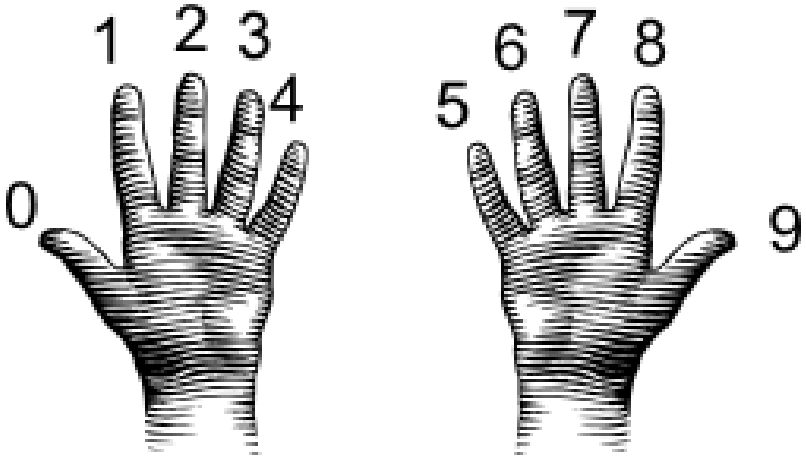
Decimal



(from i-programmer.info)

00 01 02 03 04 05 06 07 08 09
10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29
30 31 32 33 34 35 36 37 38 39
40 41 42 43 44 45 46 47 48 49

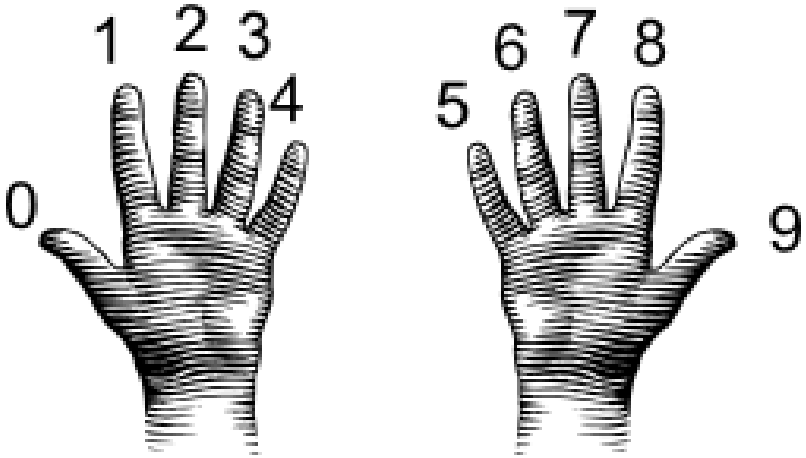
Decimal



(from i-programmer.info)

00	01	02	03	04	05	06	07	08	09
10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59

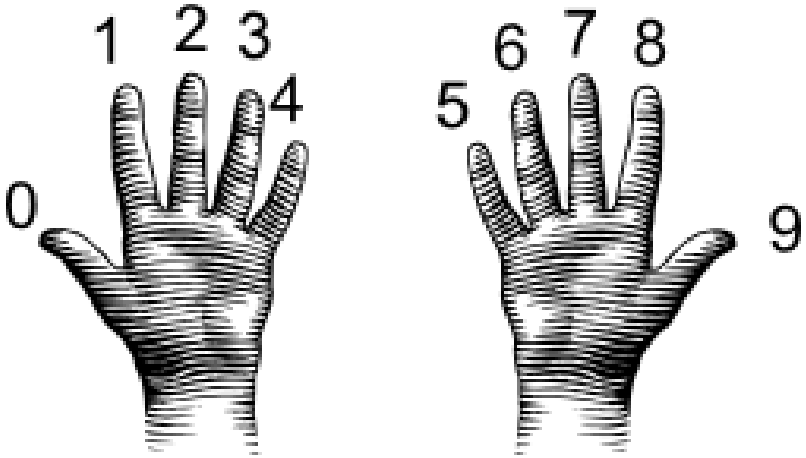
Decimal



(from i-programmer.info)

00	01	02	03	04	05	06	07	08	09
10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69

Decimal



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00	01	02	03	04	05	06	07	08	09
10	11	12	13	14	15	16	17	18	19
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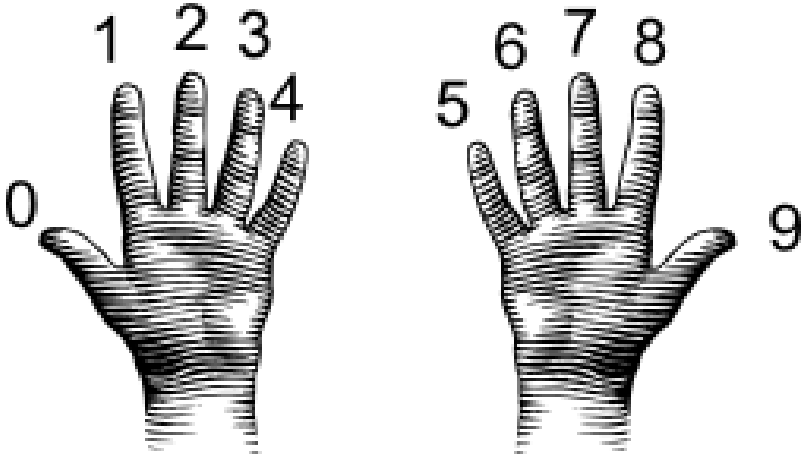
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79

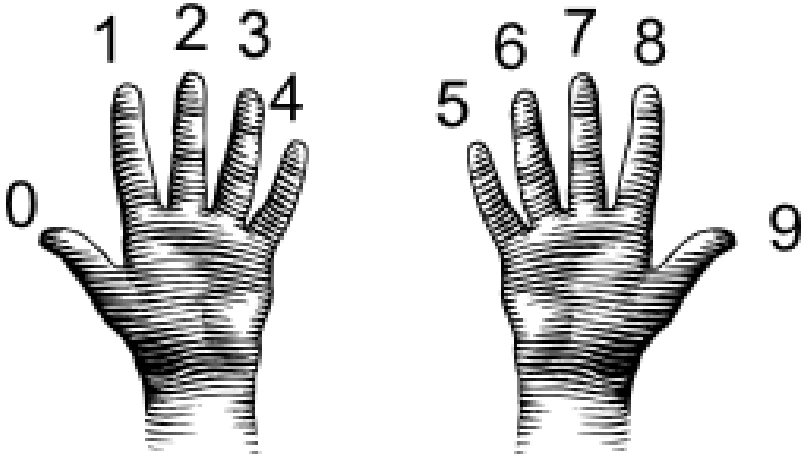
Decimal



(from i-programmer.info)

00	01	02	03	04	05	06	07	08	09
10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89

Decimal



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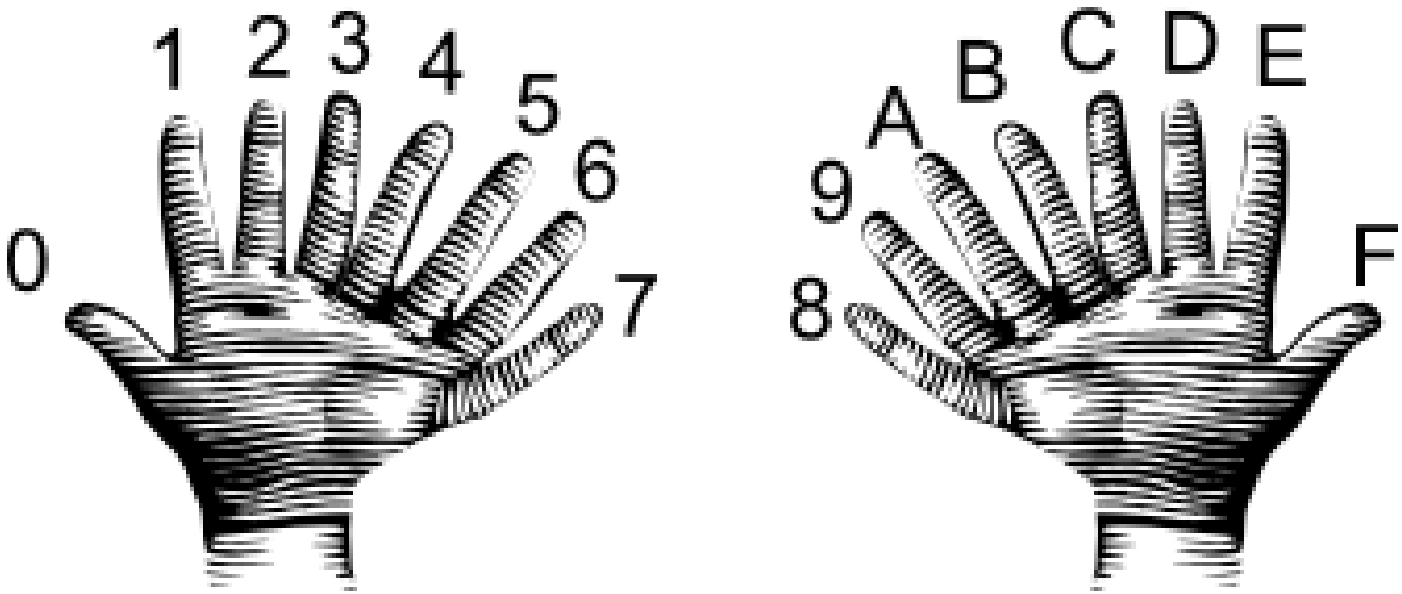
00	01	02	03	04	05	06	07	08	09
10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89
90	91	92	93	94	95	96	97	98	99

Decimal & Hexadecimal Numbers

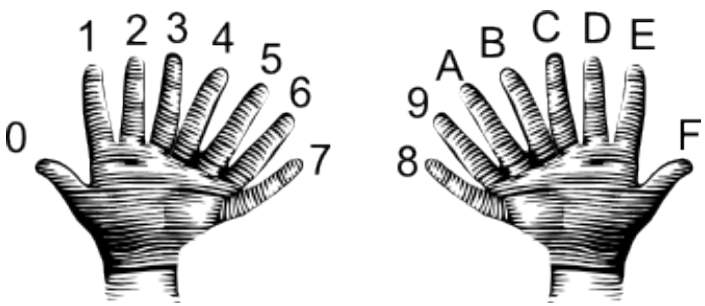
Counting with 16 digits:



(from i-programmer.info)

Hexadecimal

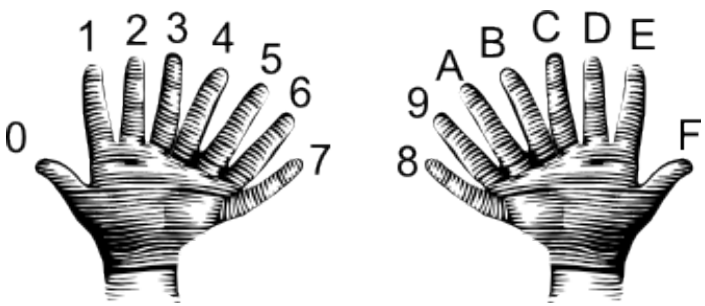
```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
```



(from i-programmer.info)

Hexadecimal

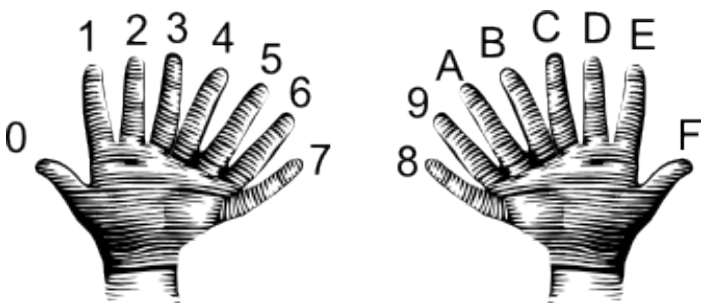
```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
```



(from i-programmer.info)

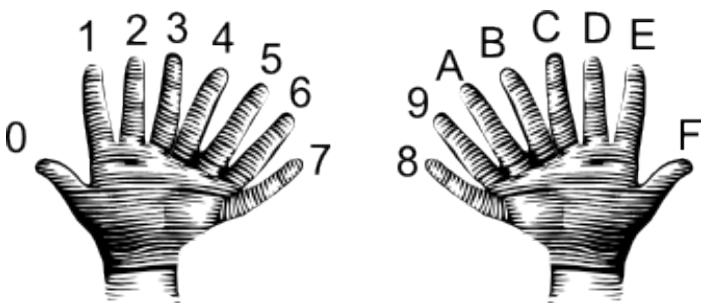
Hexadecimal

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
```



(from i-programmer.info)

Hexadecimal



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00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
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30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
```
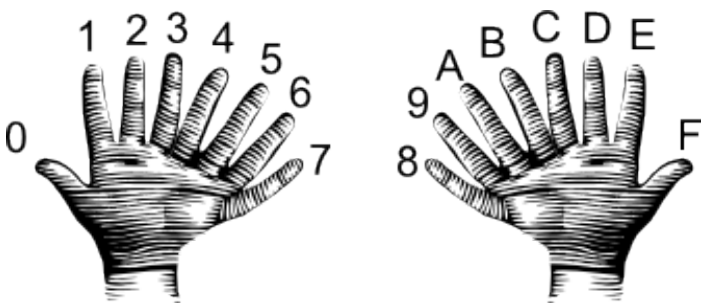

Hexadecimal



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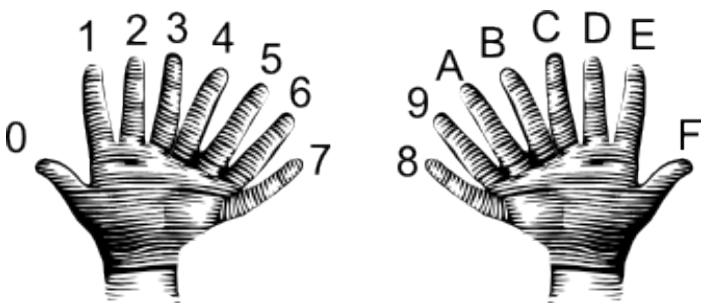
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
```

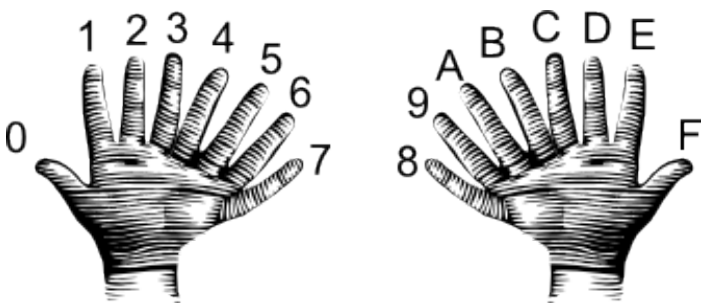
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
```

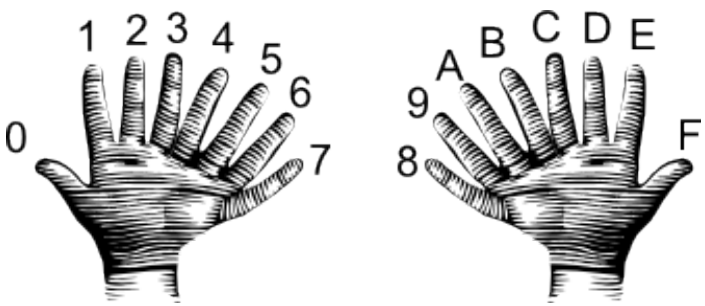
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
```

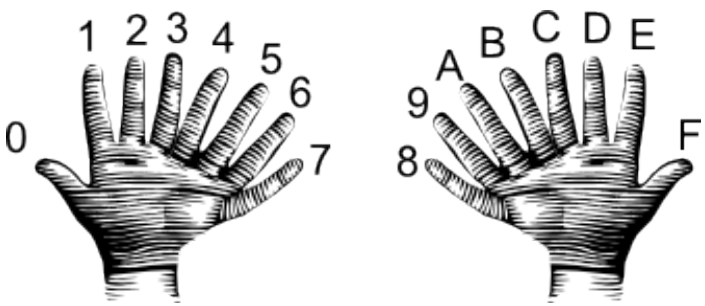
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
```

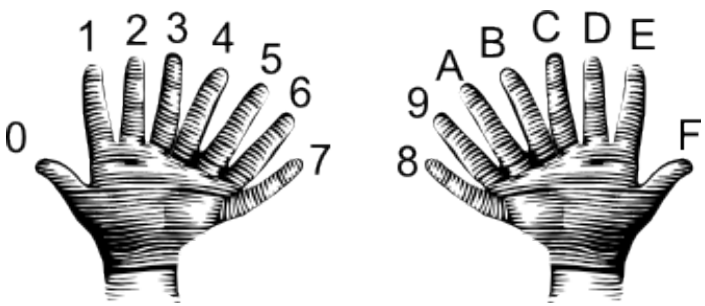
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
```

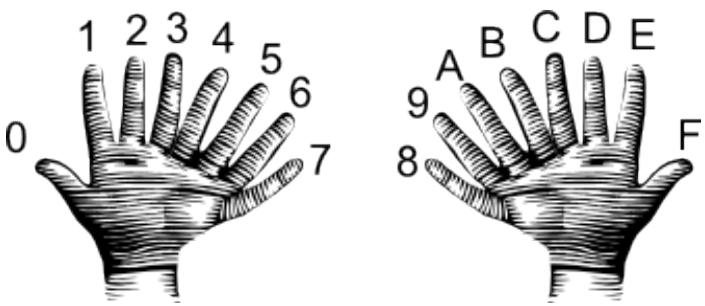
Hexadecimal



(from i-programmer.info)

```
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
```

Hexadecimal



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40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
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90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
```
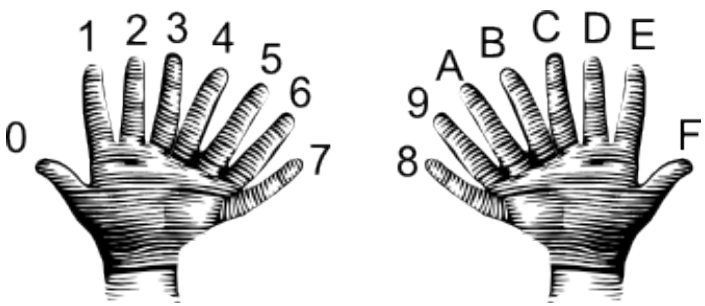

Hexadecimal



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30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
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80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
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B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
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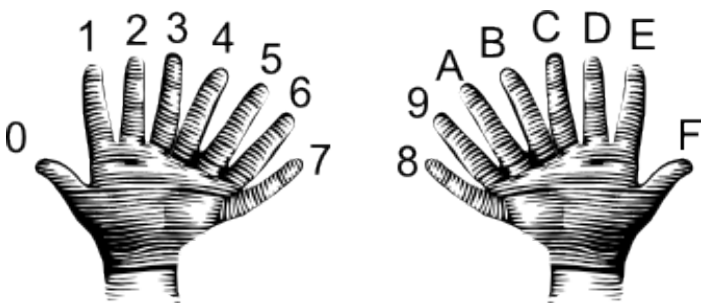

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70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
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90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
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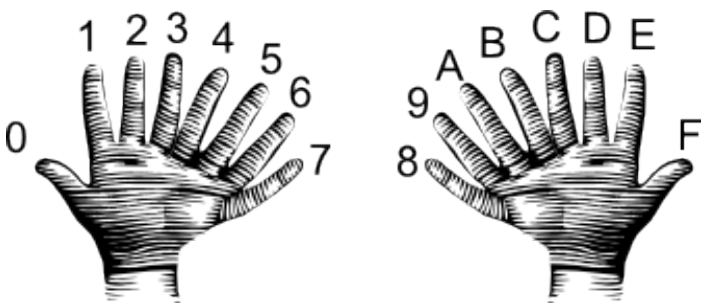
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
```

Hexadecimal



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10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
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C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF
```
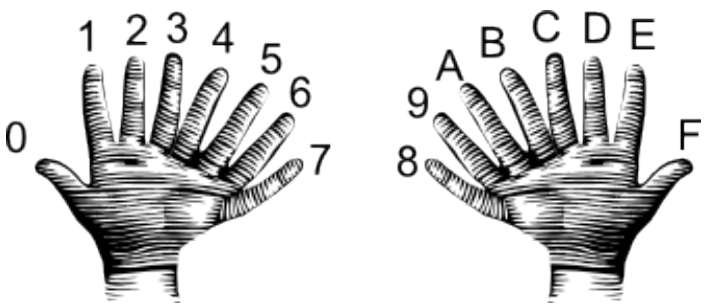

Hexadecimal



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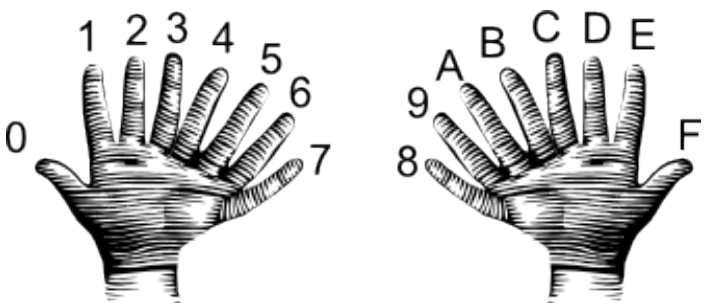
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF
E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF
```

Hexadecimal



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B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF
E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF
F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC FD FE FF
```

Colors

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

- Can specify by numbers (RGB):
  - Fractions of each:
    e.g. `(1.0, 0, 0)` is 100% red, no green, and no blue.
  - 8-bit colors: numbers from 0 to 255:
    e.g. `(0, 255, 0)` is no red, 100% green, and no blue.
  - Hexcodes (base-16 numbers):

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  - Hexcodes (base-16 numbers):
    e.g. `#0000FF` is no red, no green, and 100% blue.

In Pairs or Triples...

Some review and some novel challenges:

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

Trinkets

```
1  import turtle
2  teddy = turtle.Turtle()
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5  for c in names:
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15 hexNames = ["#FF00FF", "#990099", "#550055", "#111111"]
16 for c in hexNames:
17   teddy.color(c)
18   teddy.left(60)
19   teddy.forward(40)
20   teddy.dot(10)
```
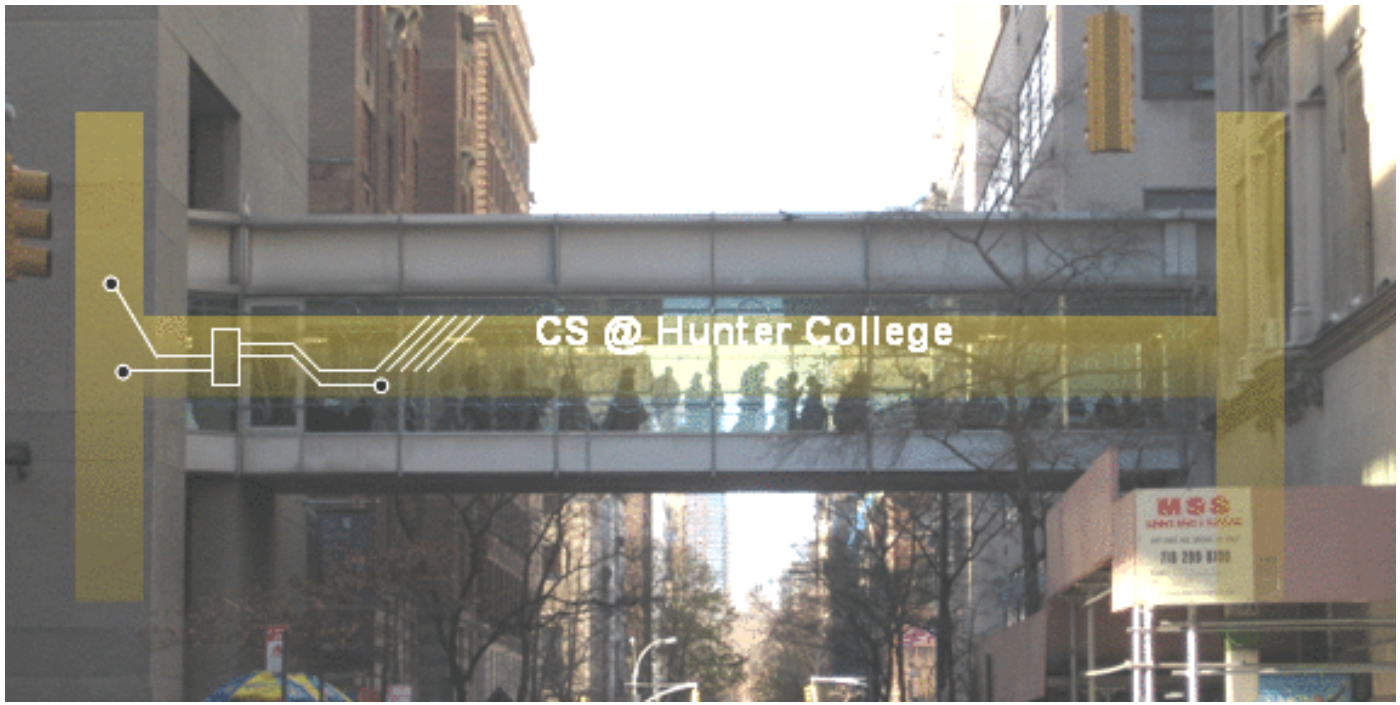

(Demo with `trinkets`)

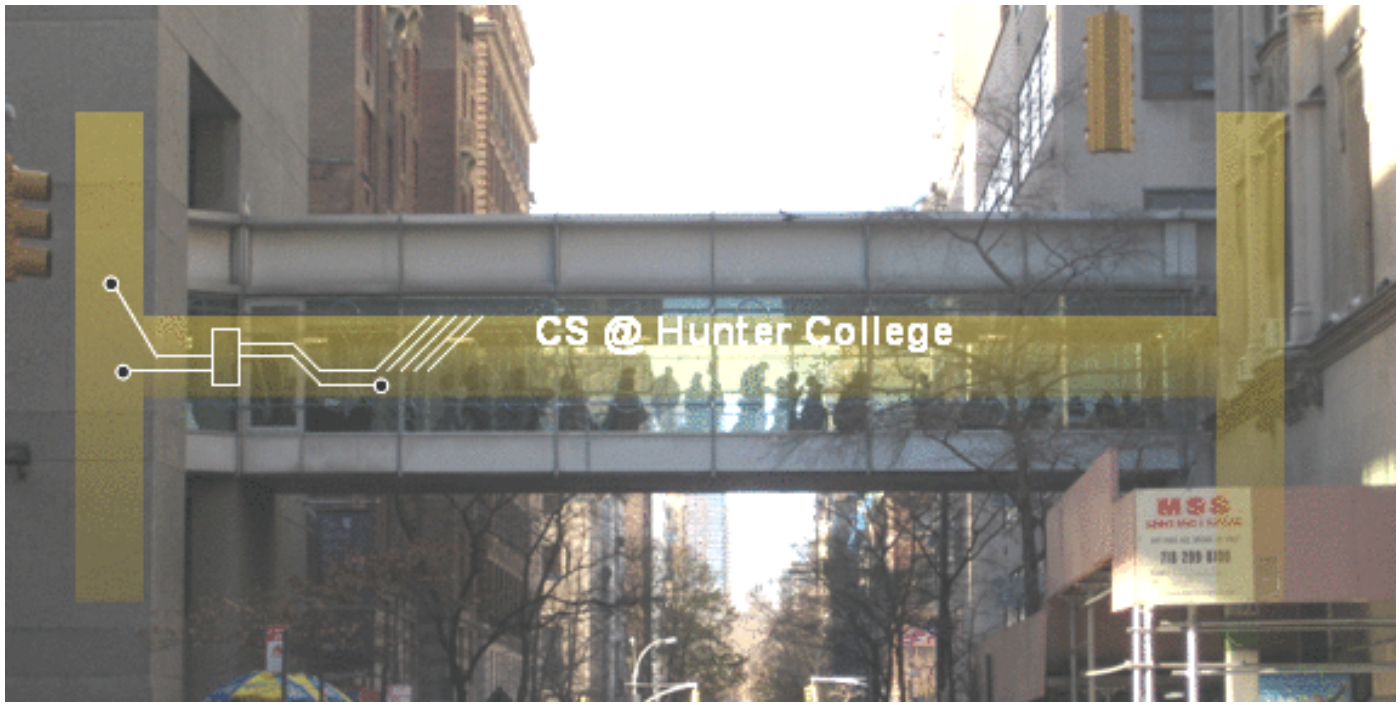
Today's Topics

- Arithmetic
- Indexing and Slicing Lists
- Colors & Hexadecimal Notation
- **2D Arrays & Image Files**
- Design Challenge: Planes

Images

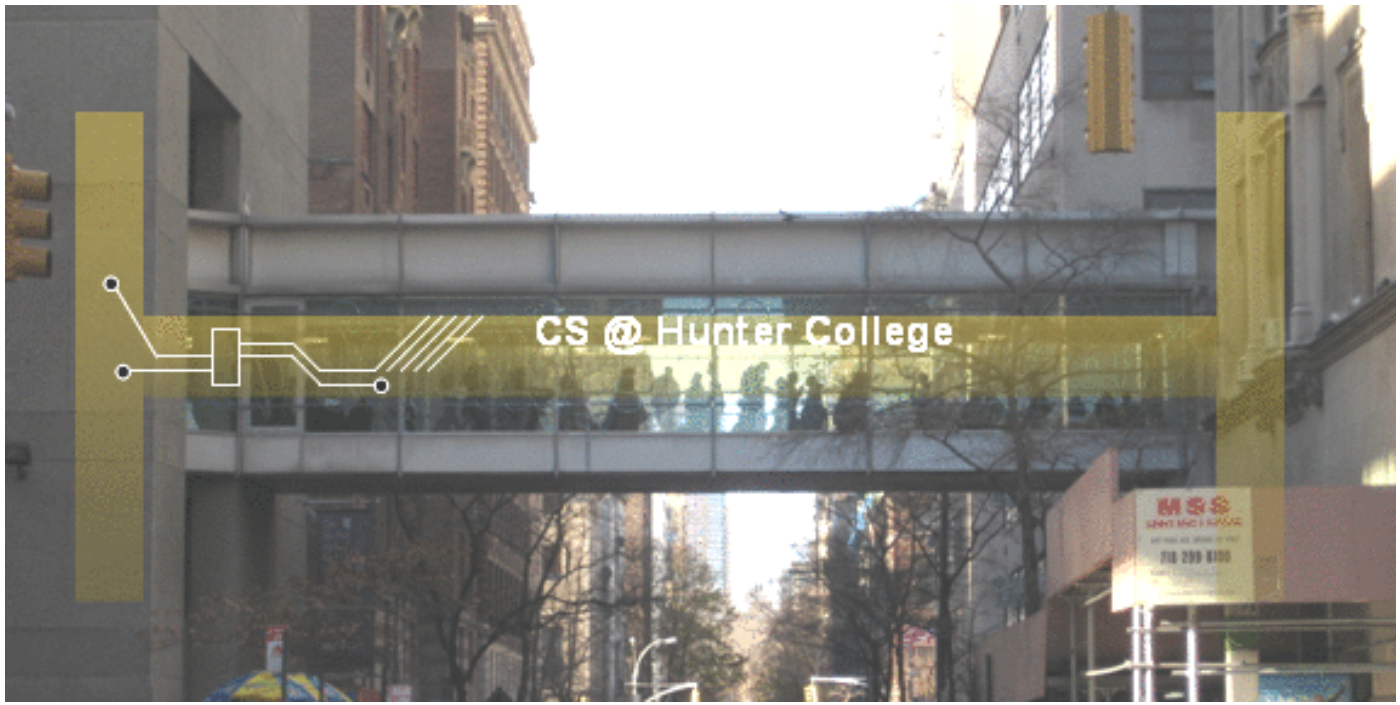


Images



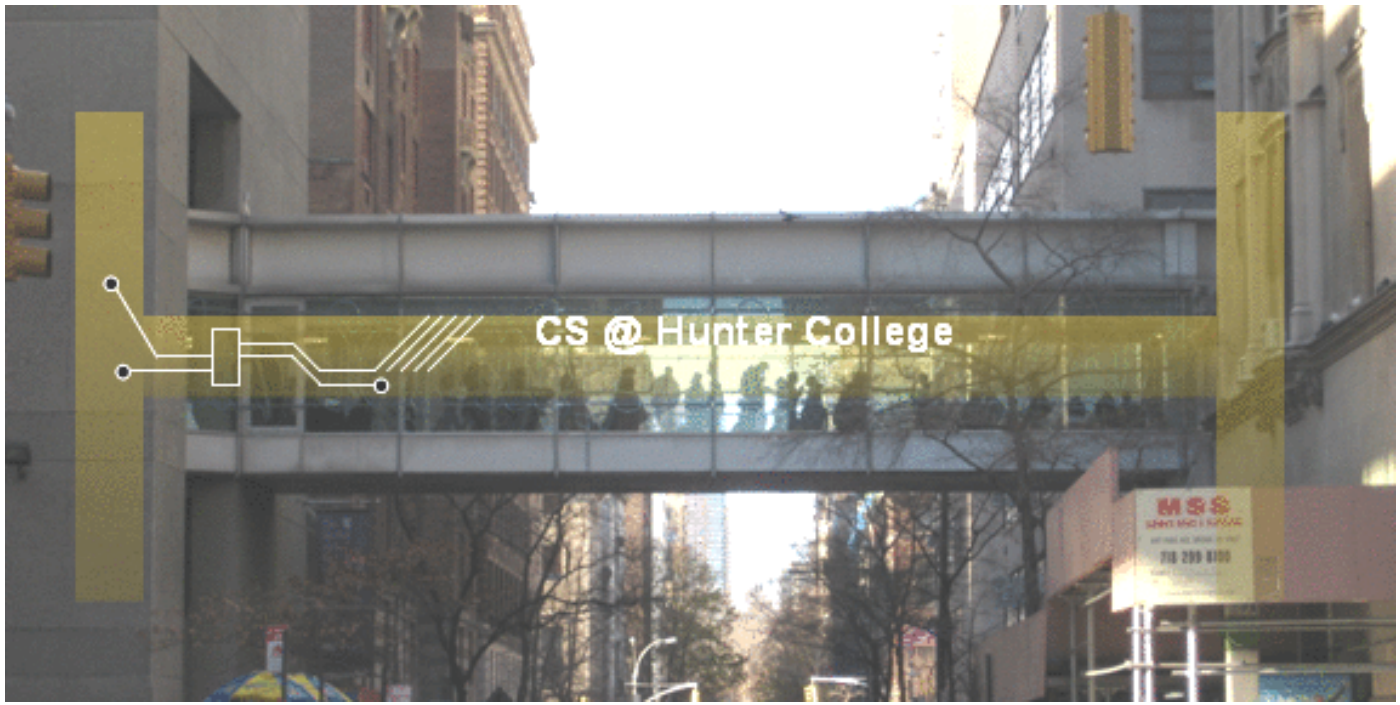
- We will use the standard portable network graphics (PNG) file format.

Images



- We will use the standard portable network graphics (PNG) file format.
- Saves every picture element (or 'pixel')–

Images



- We will use the standard portable network graphics (PNG) file format.
- Saves every picture element (or 'pixel')– often called a lossless format.

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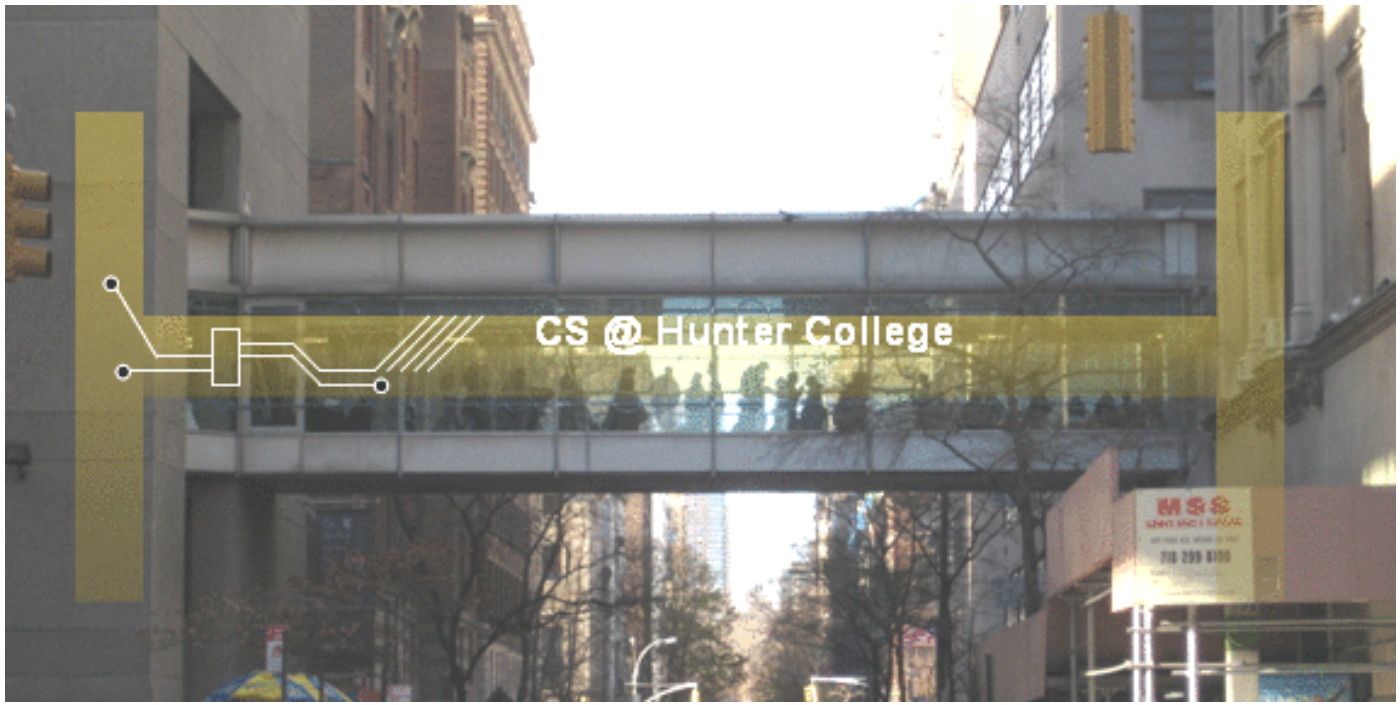
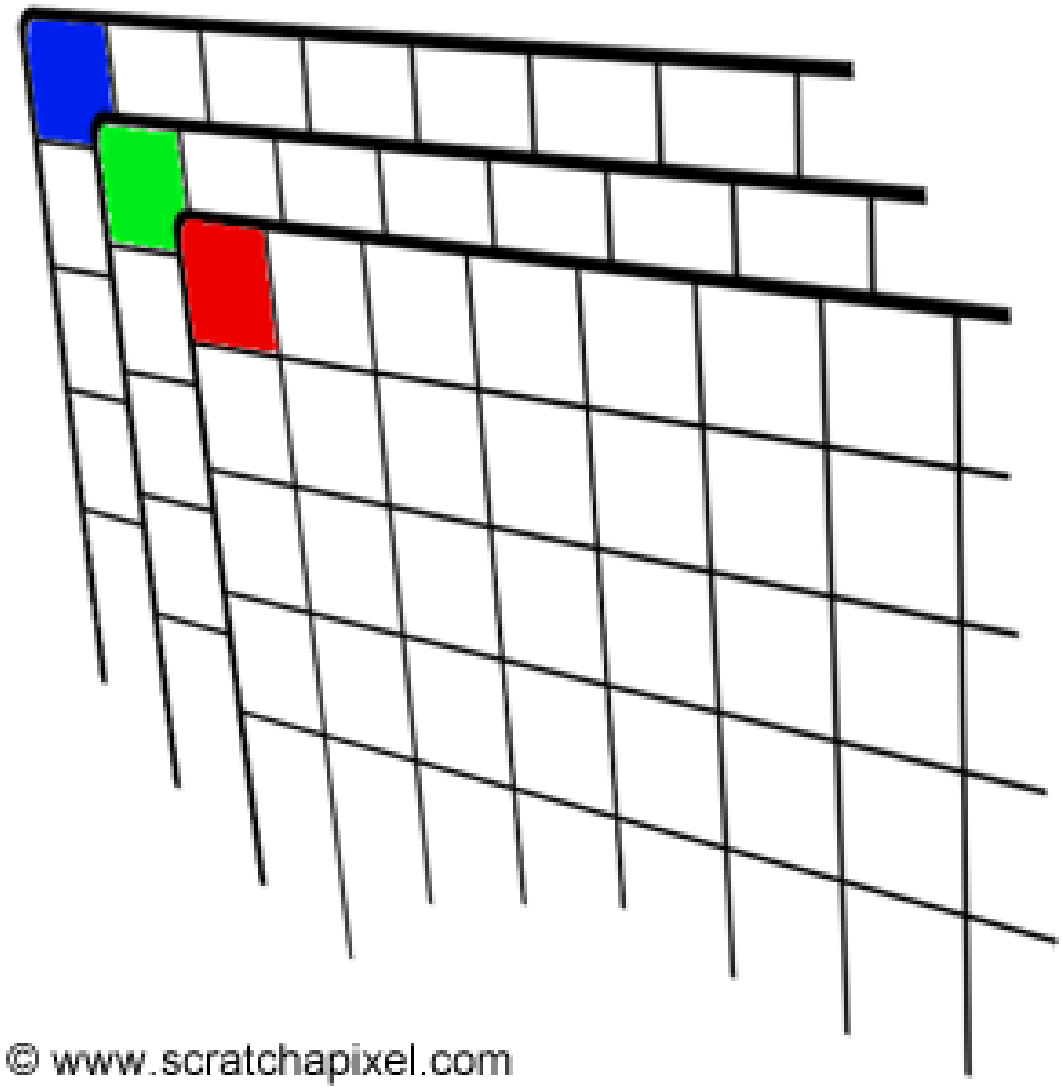
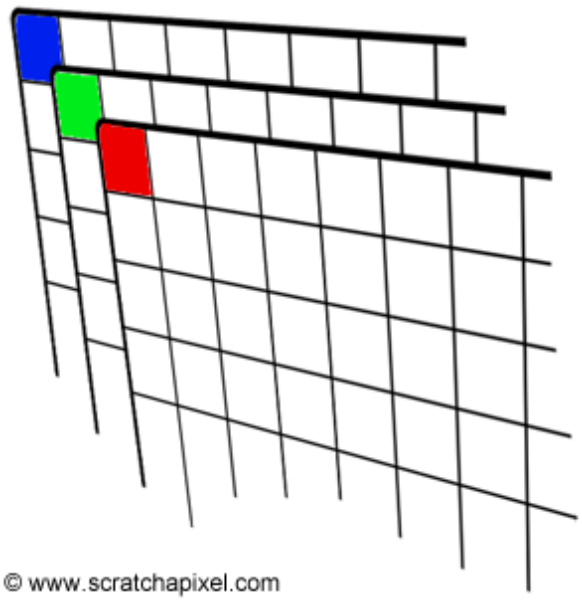


- We will use the standard portable network graphics (PNG) file format.
- Saves every picture element (or 'pixel')– often called a lossless format.
- Keeps track of the amount of red, blue, and green of each pixel.

Images



Images



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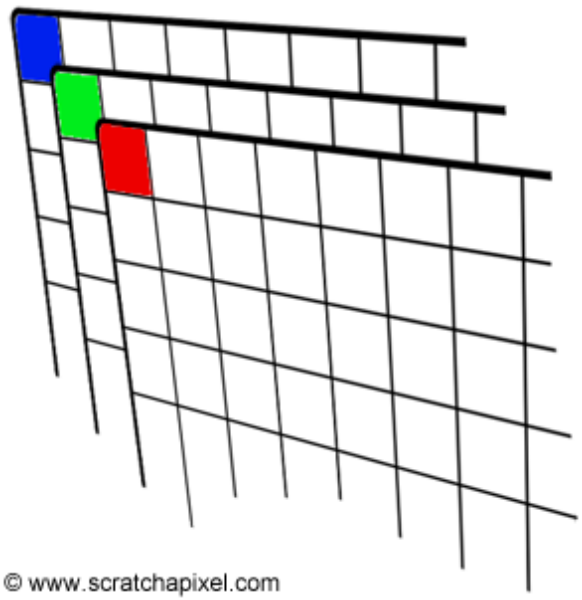

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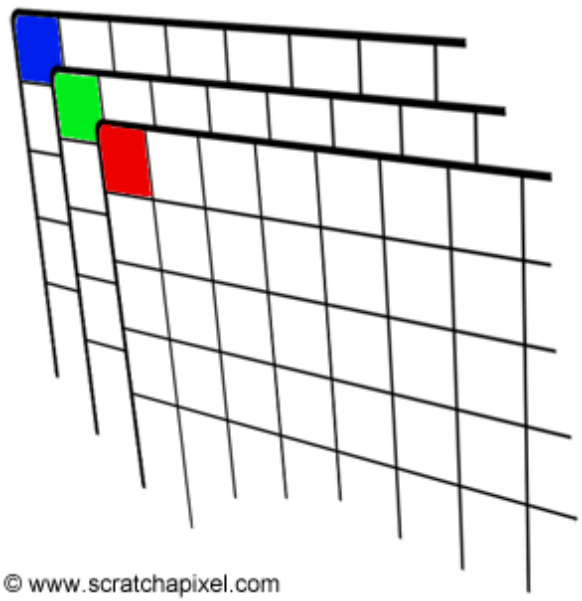
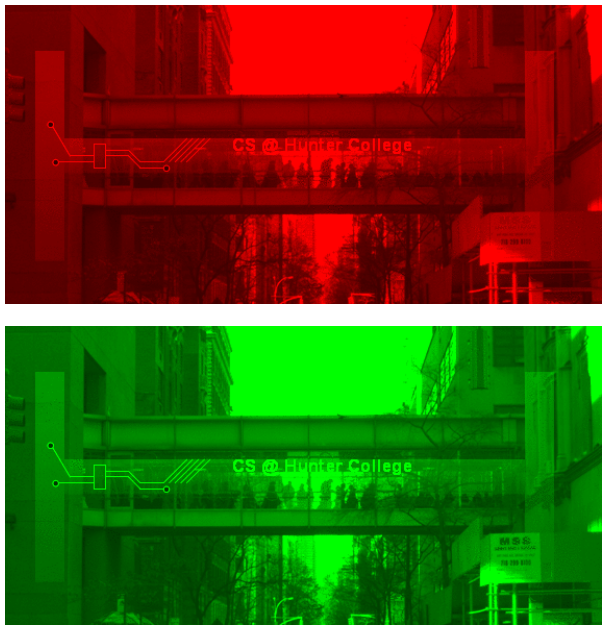
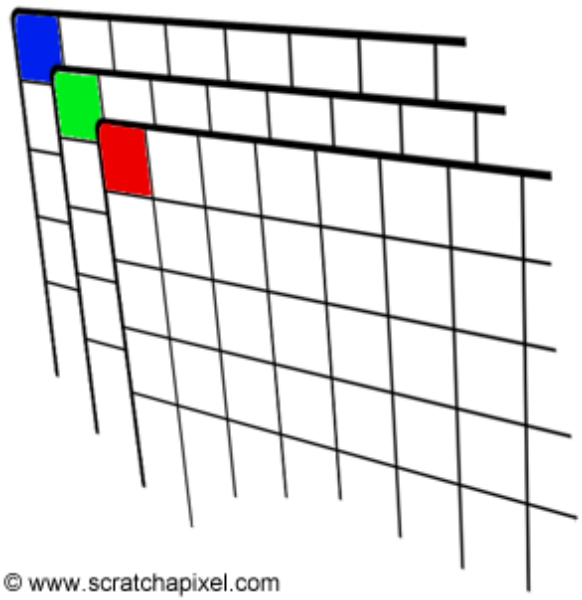
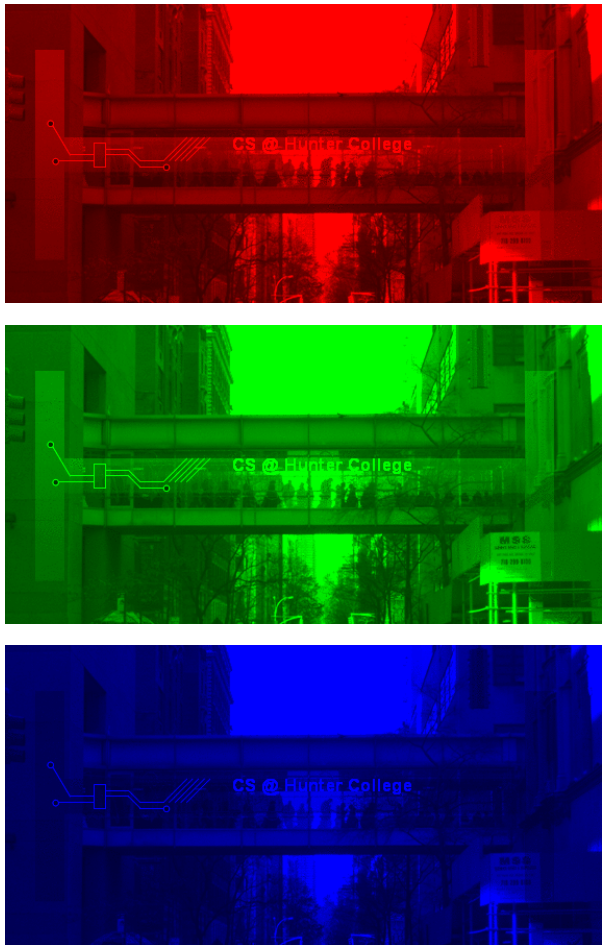




Images


© www.scratchapixel.com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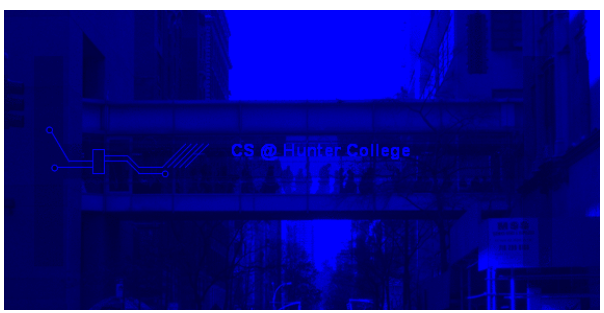
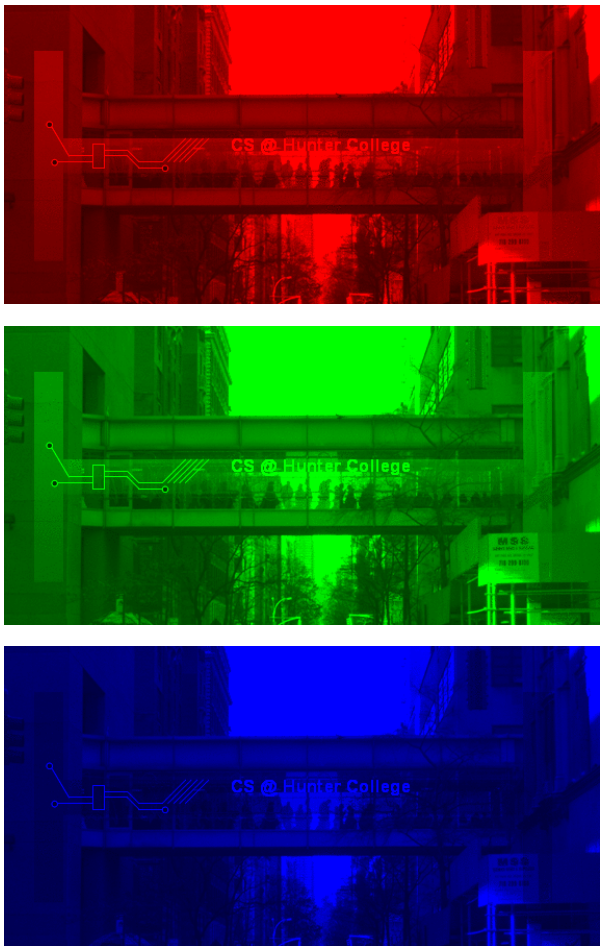
Useful Packages



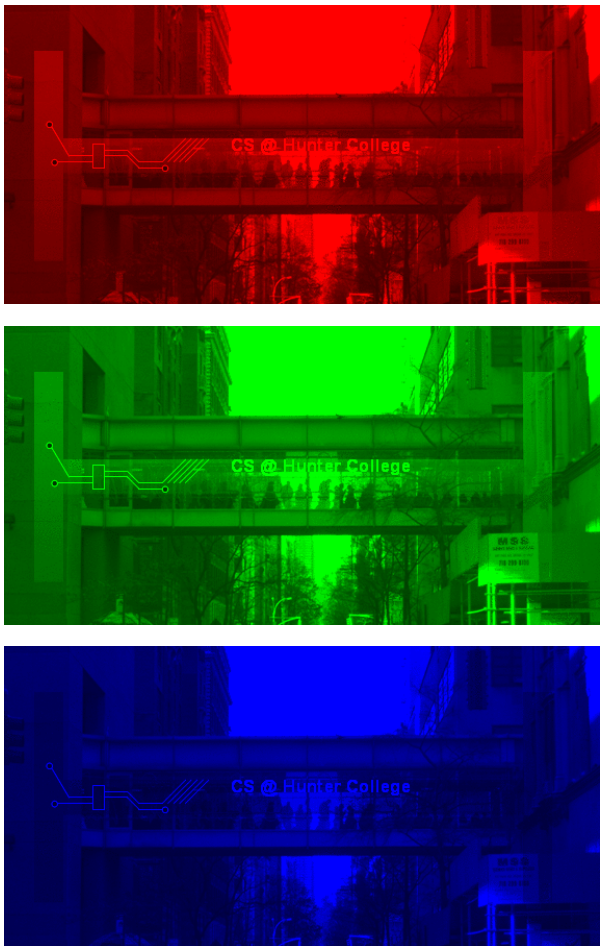
- We will use 2 useful packages for images:

Useful Packages



- We will use 2 useful packages for images:
  - `numpy`: numerical analysis package

Useful Packages



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  - `numpy`: numerical analysis package
  - `pyplot`: part of `matplotlib` for making graphs and plots

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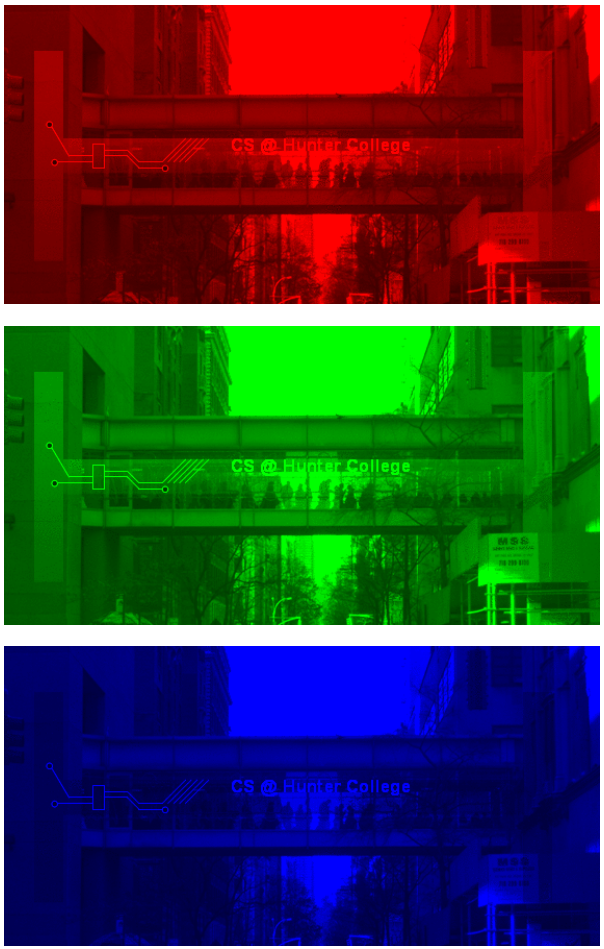
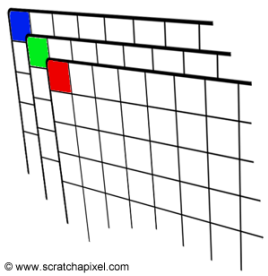


- We will use 2 useful packages for images:
  - `numpy`: numerical analysis package
  - `pyplot`: part of `matplotlib` for making graphs and plots
- See lab notes for installing on your home machine.

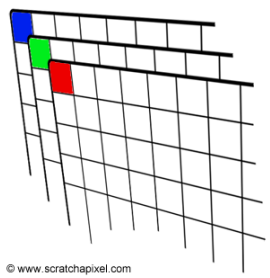
Images with pyplot and numpy




```
#Import the packages for images and arrays:
import matplotlib.pyplot as plt
import numpy as np


img = plt.imread('csBridge.png')    #Read in image from csBridge.png
plt.imshow(img)                      #Load image into pyplot
plt.show()                           #Show the image (waits until close

img2 = img.copy()          #make a copy of our image
img2[:,:,1] = 0            #Set the green channel to 0
img2[:,:,2] = 0            #Set the blue channel to 0

plt.imshow(img2)           #Load our new image into pyplot
plt.show()                 #Show the image (waits until closed to conti

plt.imsave('reds.png', img2)  #Save the image we created to the file:
```

Creating Images

To create an image from scratch:



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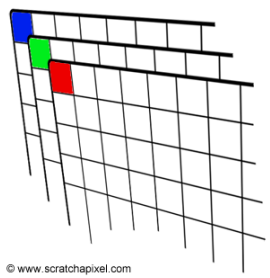

Creating Images

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1. Import the libraries.

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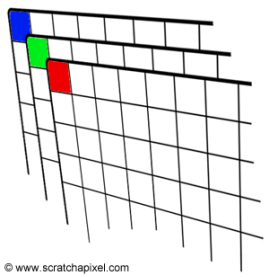
import matplotlib.pyplot as plt
import numpy as np
```



Creating Images

To create an image from scratch:

1. Import the libraries.

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import matplotlib.pyplot as plt
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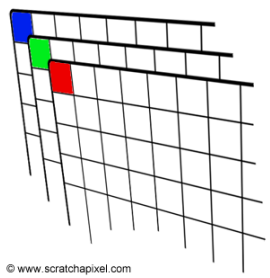
2. Create the image– easy to set all color



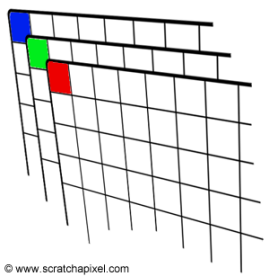
Creating Images

To create an image from scratch:

1. Import the libraries.

```
import matplotlib.pyplot as plt
import numpy as np
```

2. Create the image– easy to set all color
   1. to 0% (black):



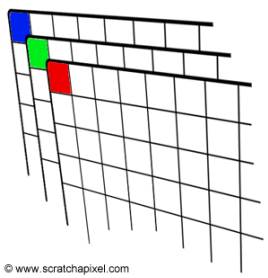
Creating Images

To create an image from scratch:

1. Import the libraries.

   ```
   import matplotlib.pyplot as plt
   import numpy as np
   ```

2. Create the image– easy to set all color
   1. to 0% (black):
      ```
      img = np.zeros((num,num,3))
      ```



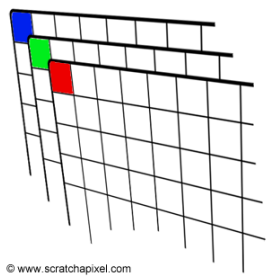
Creating Images

To create an image from scratch:

1. Import the libraries.

```
import matplotlib.pyplot as plt
import numpy as np
```

2. Create the image– easy to set all color
   1. to 0% (black):
      `img = np.zeros((num,num,3))`
   2. to 100% (white):



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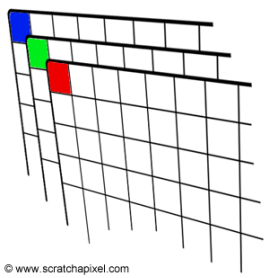

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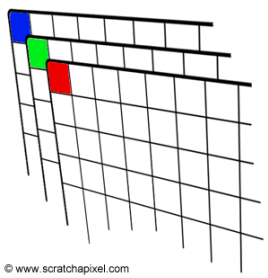

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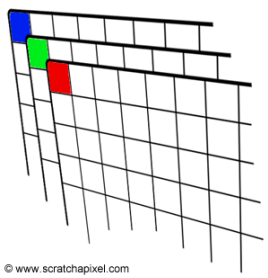

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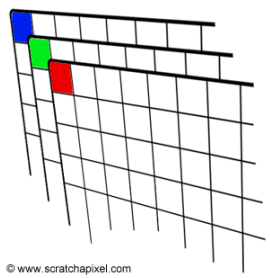

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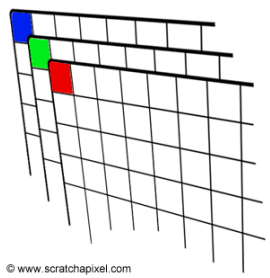

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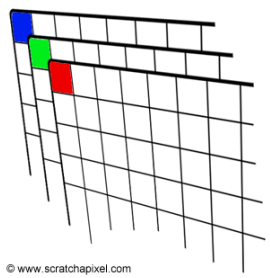

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```
plt.imsave('myImage.png', img)
```

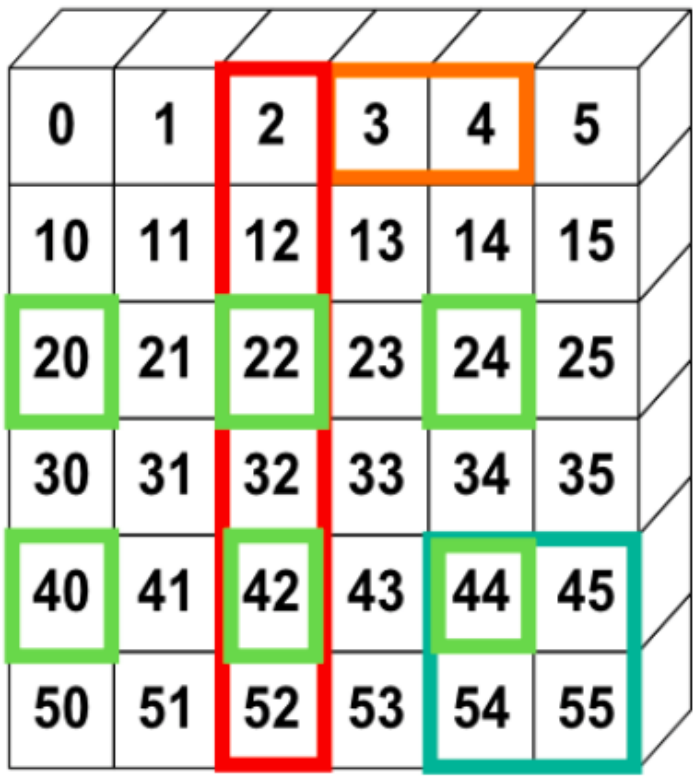
More on numpy arrays

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

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

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

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



numpy tutorial

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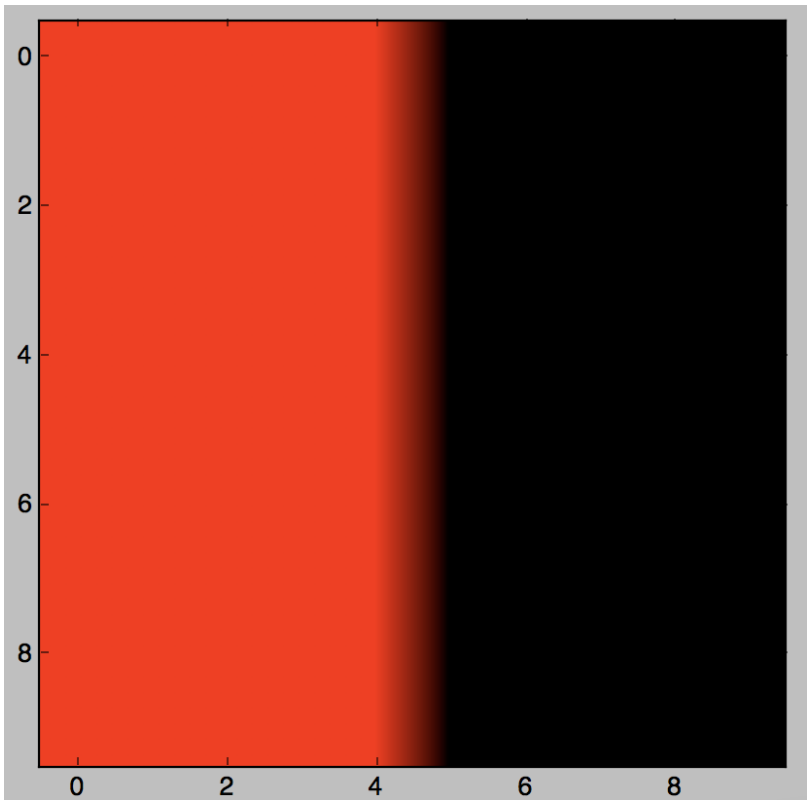
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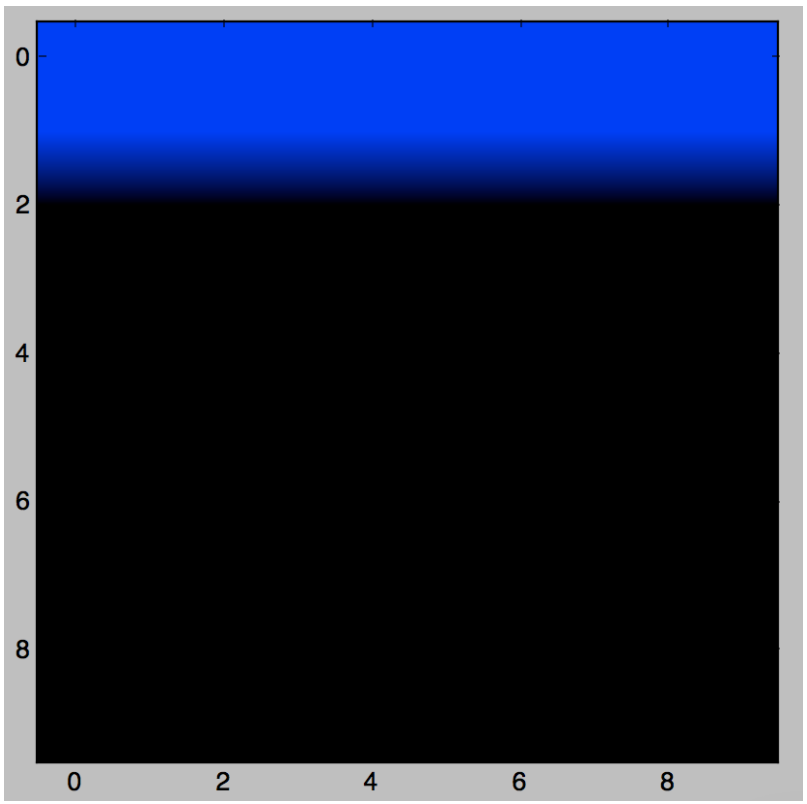
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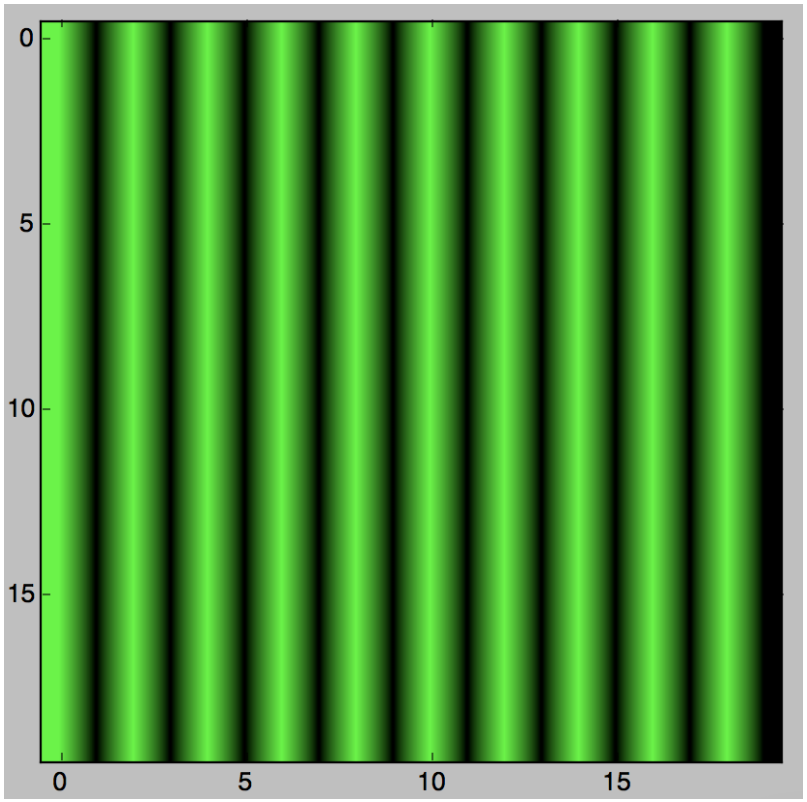
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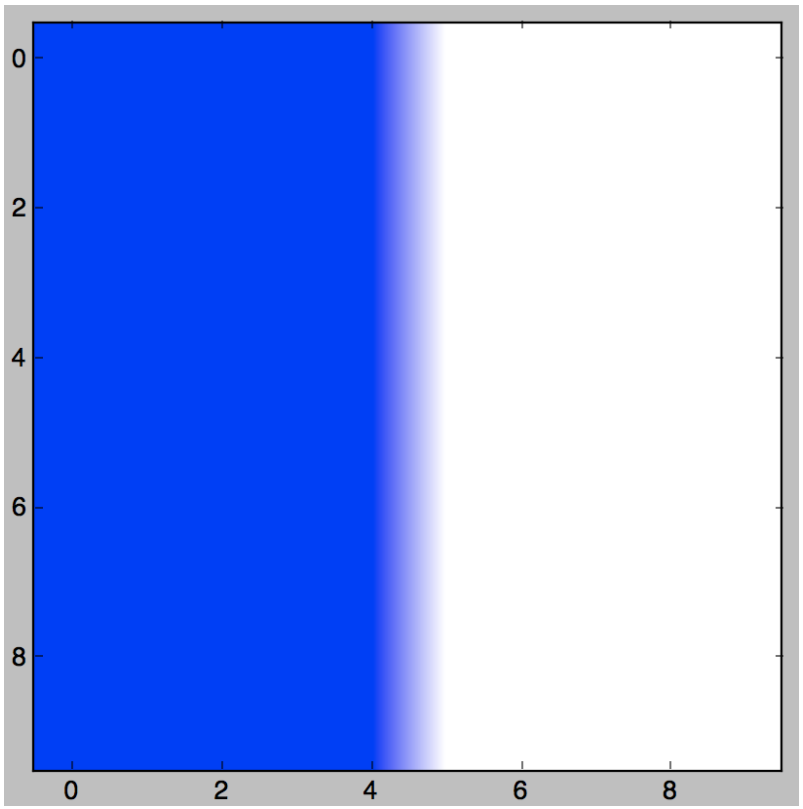
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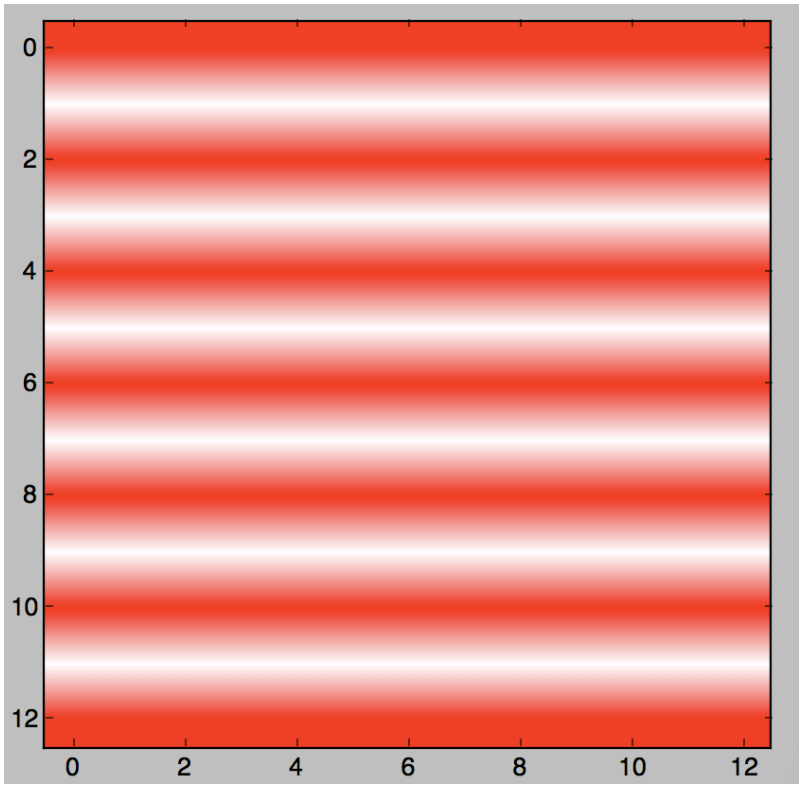
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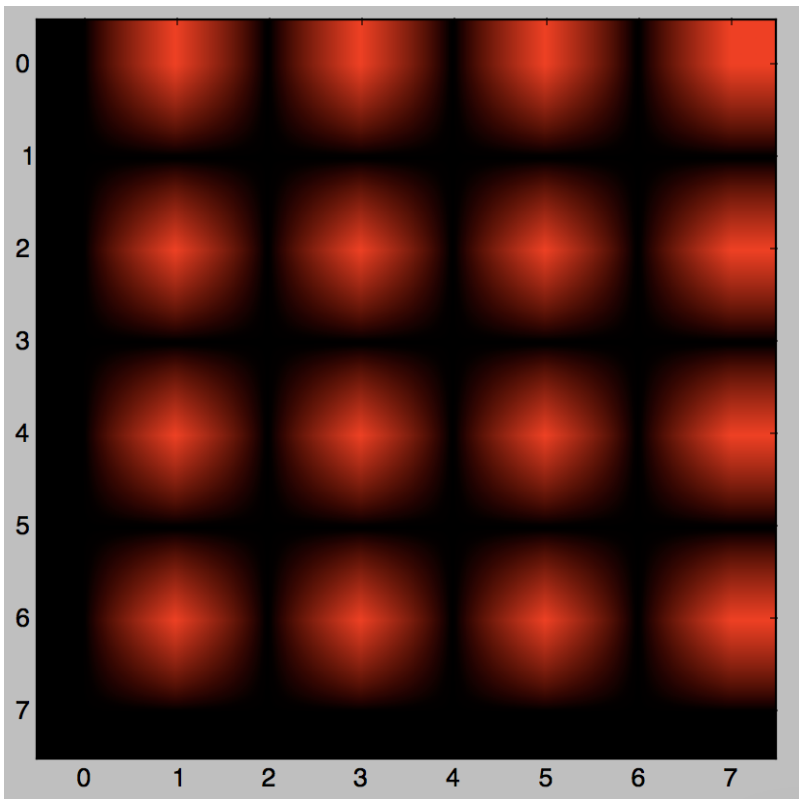
    ```
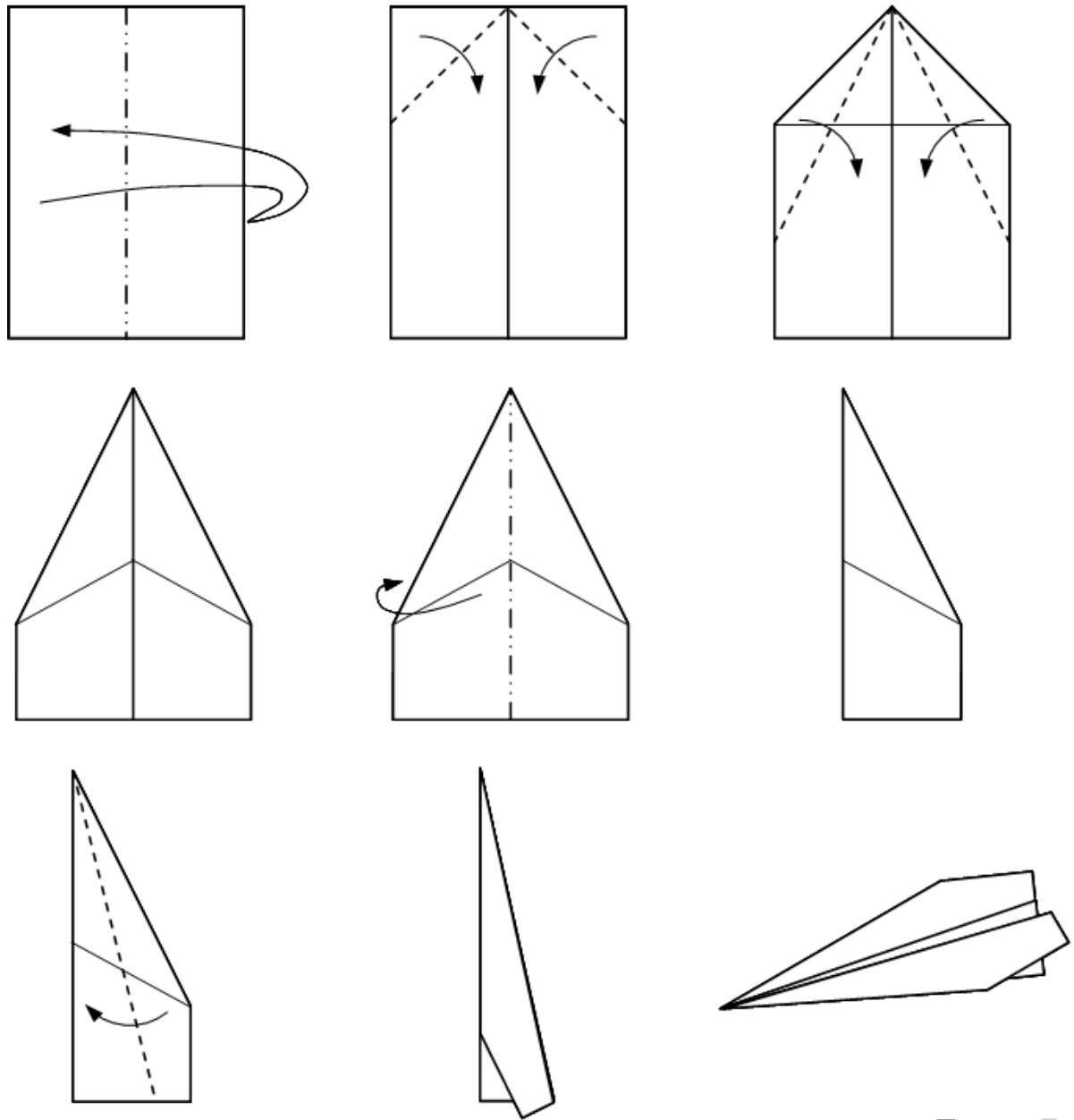

Today's Topics

- Arithmetic
- Indexing and Slicing Lists
- Colors & Hexadecimal Notation
- 2D Arrays & Image Files
- **Design Challenge: Planes**

Design Challenge: Planes



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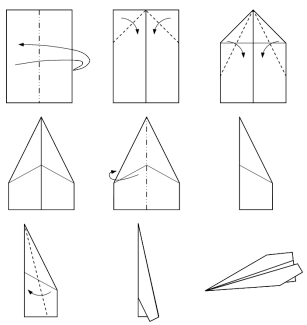

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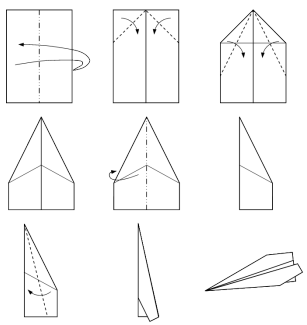

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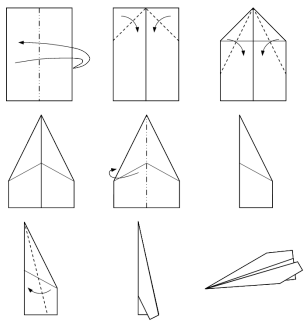

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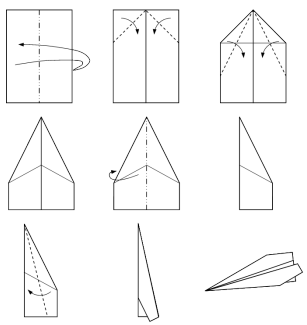

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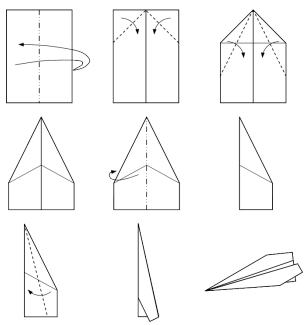

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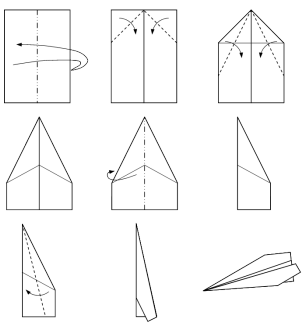

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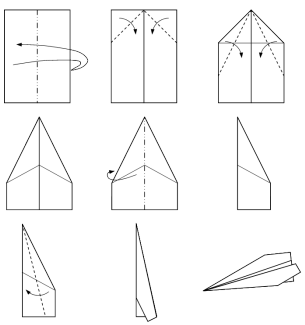

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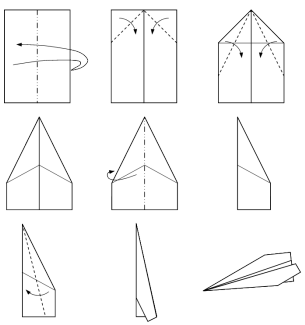

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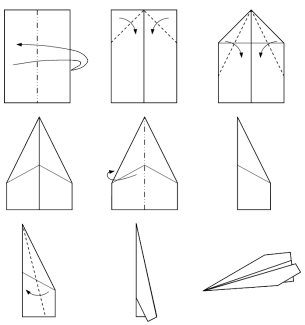

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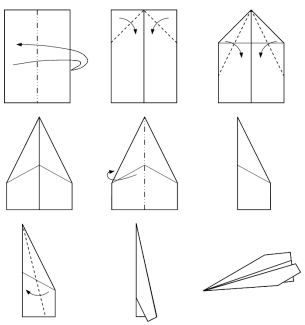

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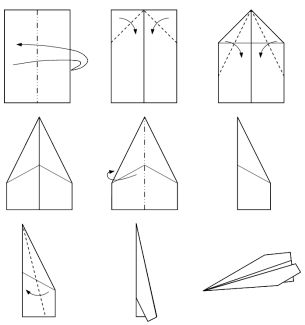

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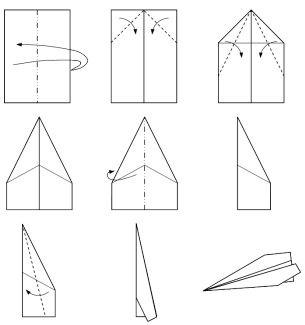

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- Remember to pick up all your airplanes!

Recap

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

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- Pass your lecture slips to the end of the rows for the UTA's to collect.

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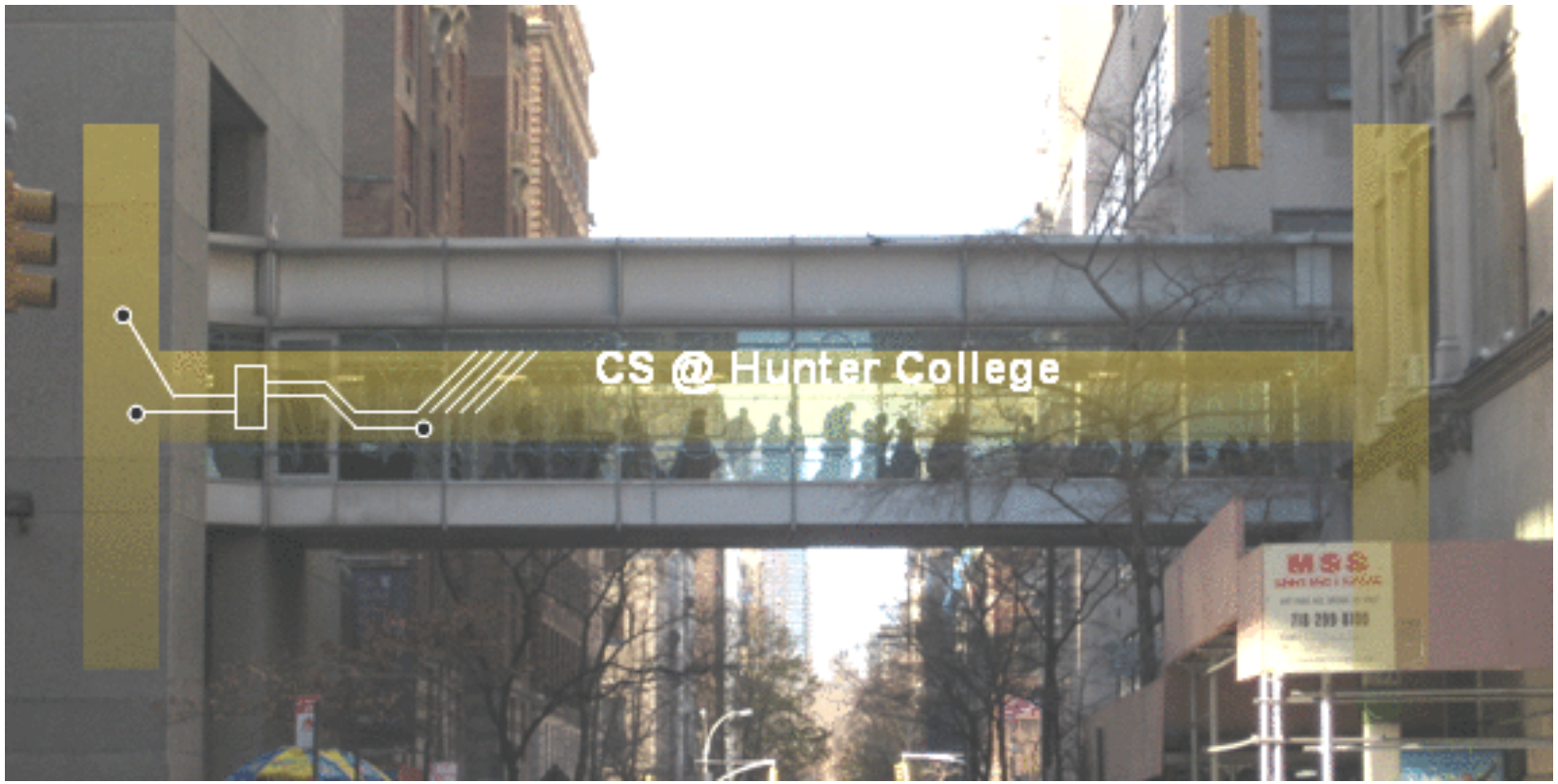
  - followed by answer; and
  - repeat.
- Past exams are on the webpage (under Final Exam Information).

Practice Quiz & Final Questions

- Since you must pass the final exam to pass the course, we end every lecture with final exam review.
- Pull out something to write on (not to be turned in).
- Lightning rounds:
  - write as much you can for 60 seconds;
  - followed by answer; and
  - repeat.
- Past exams are on the webpage (under Final Exam Information).
- We're starting with Fall 2017, Version 2.

Writing Boards



- Return writing boards as you leave...