

Squeaky Hinge

STEAM Clown™

Binary Numbers

Art without Engineering is dreaming. Engineering without Art is calculating.

- Steven K. Roberts

June, 2016

Let's Play A Game...

- I Need A Volunteer...
- Pick A Number Between "0" And "64"
 - So Not "0" Or "64", But Some Number Between...
- Write It Down
- Show It Around... But Don't Let Me See It
- Place it Face Down On Your Table
- Now, Tell Me "Yes" Or "No" If Your Number Is On The Next 6 Cards
- Ready...



Is your number on this card?

1	3	5	7	9	11	13	15
17	19	21	23	25	27	29	31
33	35	37	39	41	43	45	47
49	51	53	55	57	59	61	63

Is your number on this card?

2	3	6	7	10	11	14	15
18	19	22	23	26	27	30	31
34	35	38	39	42	43	46	47
50	51	54	55	58	59	62	63

Is your number on this card?

4	5	6	7	12	13	14	15
20	21	22	23	28	29	30	31
36	37	38	39	44	45	46	47
52	53	54	55	60	61	62	63

Is your number on this card?

8	9	10	11	12	13	14	15
24	25	26	27	28	29	30	31
40	41	42	43	44	45	46	47
56	57	58	59	60	61	62	63

Is your number on this card?

16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

Is your number on this card?

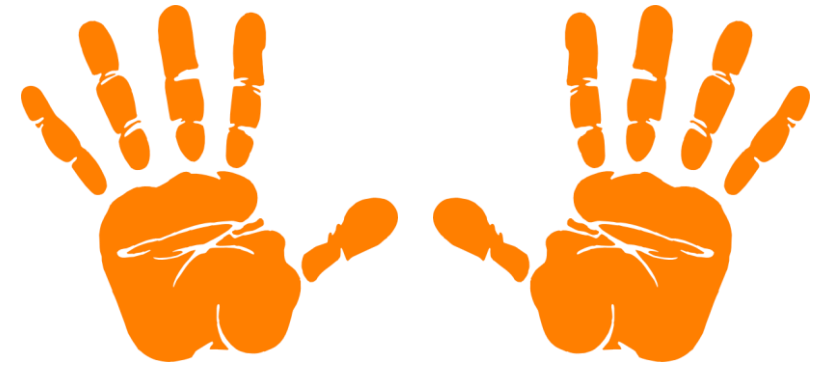
32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

Squeaky Hinge

Your Number IS.....

Why Do We Count To 10?

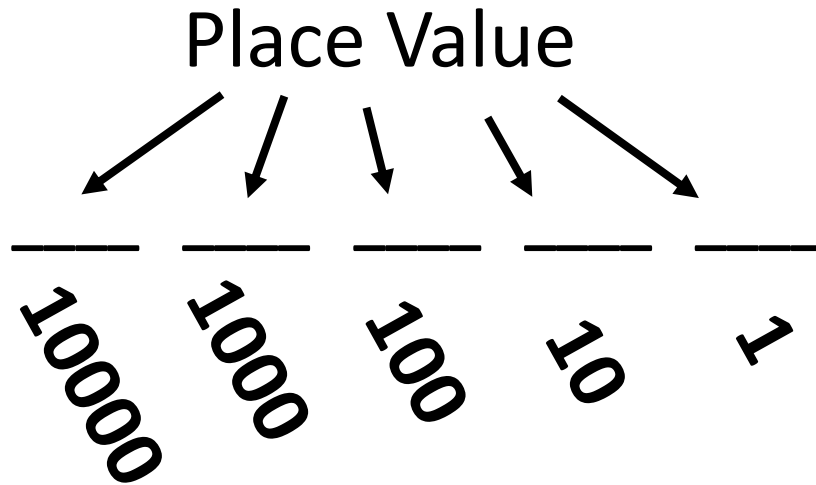
- Because We Have 10 Fingers...
- What If We Had 3 fingers?
- How About If We Only Had 1?



Lets Learn About The Binary (Base 2) Number System,
But First, Lets Review The Decimal (Base 10) Number System

Base 10 Number System - Place Value

- Which Number is bigger?
39 or 93



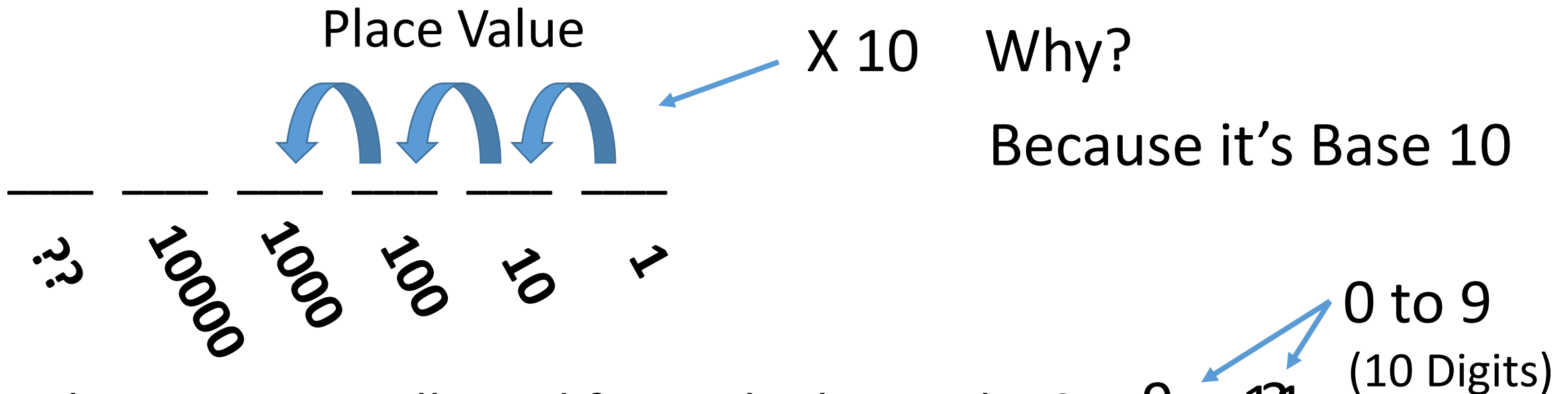
<u>3</u>	<u>9</u>	<u>9</u>	<u>3</u>
10	1	10	1

$3 \times 10 + 9 \times 1$	$9 \times 10 + 3 \times 1$
$30 + 9$	$90 + 3$

<u>5</u>	<u>6</u>	<u>3</u>	<u>9</u>
1000	100	10	1

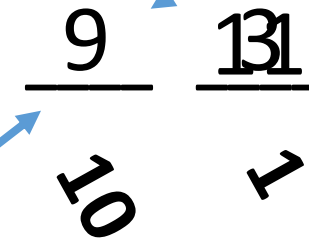
Base 10 Number System - Place Value

- How Do You move from one Place Value to the next?



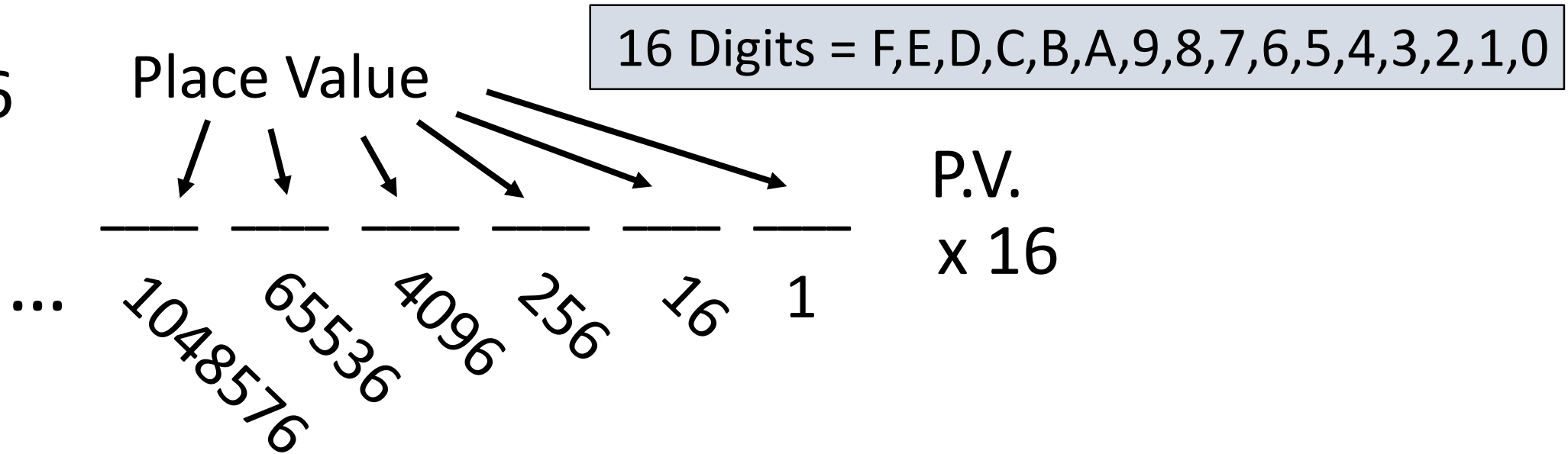
- What Digits are allowed for each Place Value?

Only Allowed One Digit Per Place Value

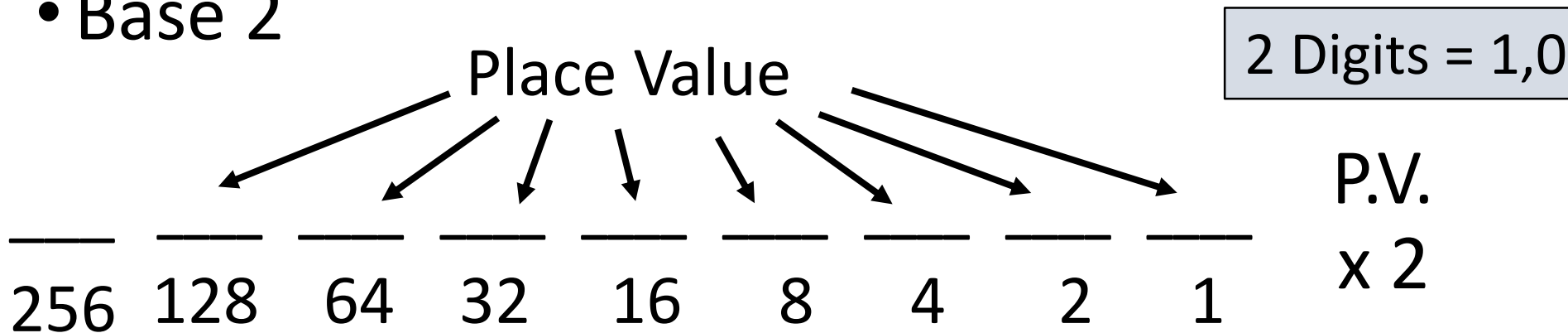


Figuring Out Other Base Number Systems

- Base 16

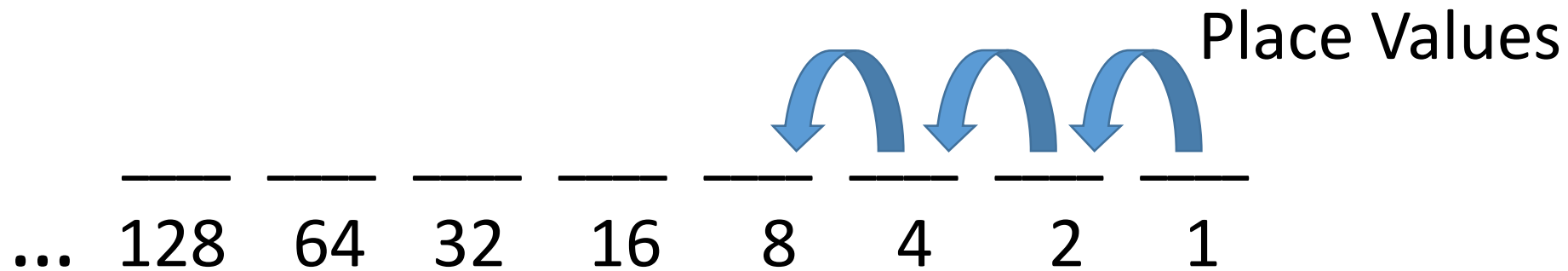


- Base 2



Base 2 Number System - Place Value

- How Do You move from one Place Value to the next?
- In Other Words, How Do You Count In Binary

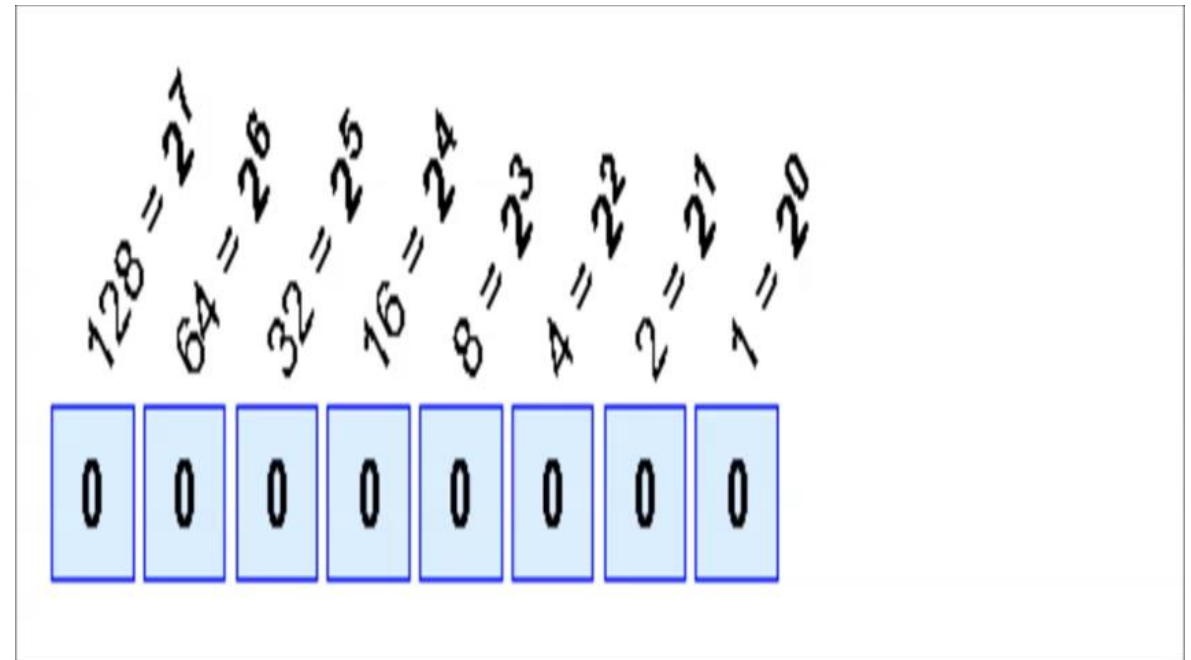


You Use The Same Rules As Decimal (Base 10)... Just In Binary (Base 2)

Counting In Binary

- Remember Binary Numbers are made of **0**s and **1**s
- Here Is An Example Of A Binary Number: **101011**
 - Binary Number can only be made from the Digits **0-1**
 - There is no **2,3,4,5,6,7,8** or **9** in Binary
- Lets Start Counting...

- Start with 0
- Then count to 1
- Then ?? There is not symbol for 2



Place Values

How To Convert From Binary or Decimal

Computer Humc

- Binary is as easy as 1, 10, 11

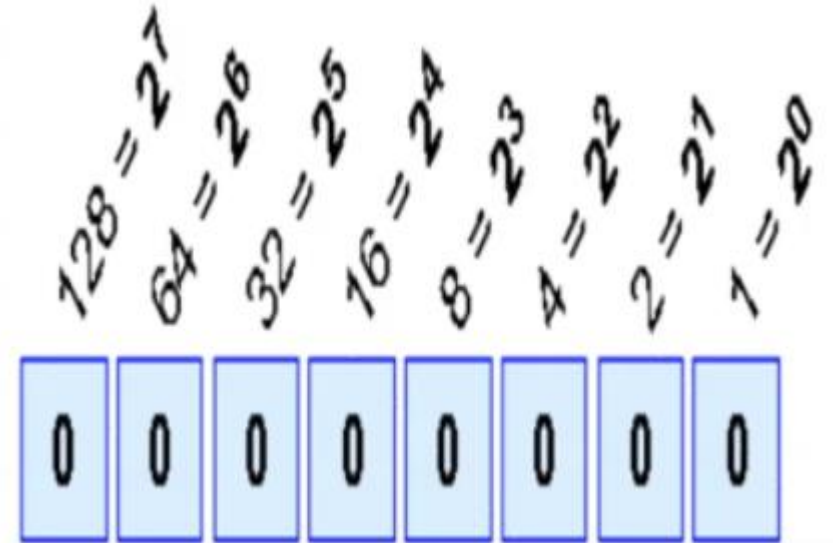
Convert the Following Binary Numbers:

$$0011 = ? \quad 1 \times 2 + 1 \times 1 = 3$$

$$1011 = ? \quad 1 \times 8 + 0 \times 4 + 1 \times 2 + 1 \times 1 = 11$$

$$10101 = ? \quad 1 \times 16 + 0 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1 = 21$$

$$110011 = ? \quad 1 \times 32 + 1 \times 16 + 0 \times 8 + 0 \times 4 + 1 \times 2 + 1 \times 1 = 51$$



Place Values

All Six Cards

8	9	10	11	12	13	14	15
24	25	26	27	28	29	30	31
40	41	42	43	44	45	46	47
56	57	58	59	60	61	62	63

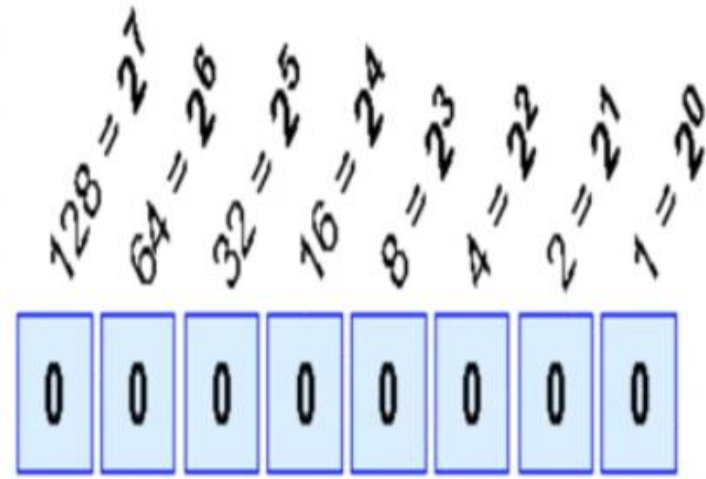
1	3	5	7	9	11	13	15
17	19	21	23	25	27	29	31
33	35	37	39	41	43	45	47
49	51	53	55	57	59	61	63

16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

2	3	6	7	10	11	14	15
18	19	22	23	26	27	30	31
34	35	38	39	42	43	46	47
50	51	54	55	58	59	62	63

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

4	5	6	7	12	13	14	15
20	21	22	23	28	29	30	31
36	37	38	39	44	45	46	47
52	53	54	55	60	61	62	63



Decimal (Base 10)	Binary (Base 2)
0	0000 0000
1	0000 0001
2	0000 0010
3	0000 0011
4	0000 0100
5	0000 0101
6	0000 0110
7	0000 0111
8	0000 1000
9	0000 1001
10	0000 1010
11	0000 1011
12	0000 1100
13	0000 1101
14	0000 1110
15	0000 1111
16	0001 0000

Worksheet - Convert From Binary or Decimal

Convert the Following Binary Numbers:

$$\mathbf{11011} = \underline{\hspace{2cm}}$$

$$\mathbf{00011011} = \underline{\hspace{2cm}}$$

$$\mathbf{11101010} = \underline{\hspace{2cm}}$$

$$\mathbf{01111101} = \underline{\hspace{2cm}}$$

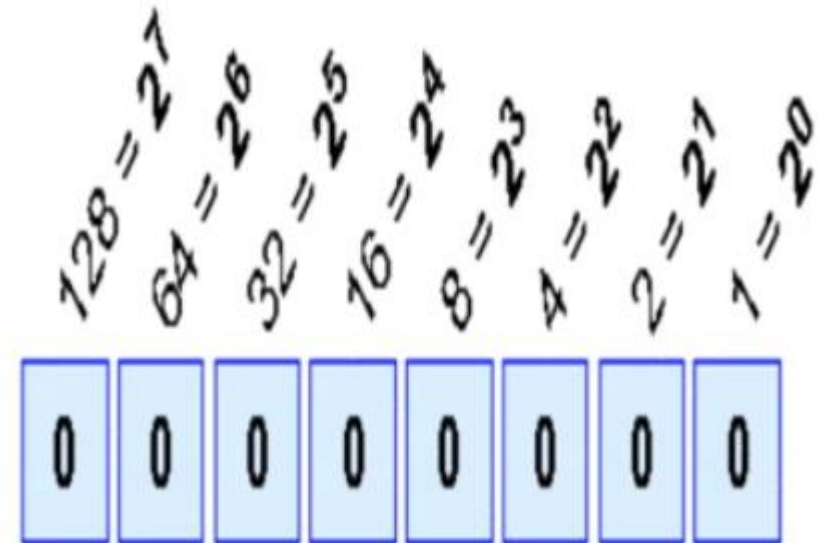
$$\mathbf{10101011} = \underline{\hspace{2cm}}$$

$$\mathbf{10101010} = \underline{\hspace{2cm}}$$

Extra Credit

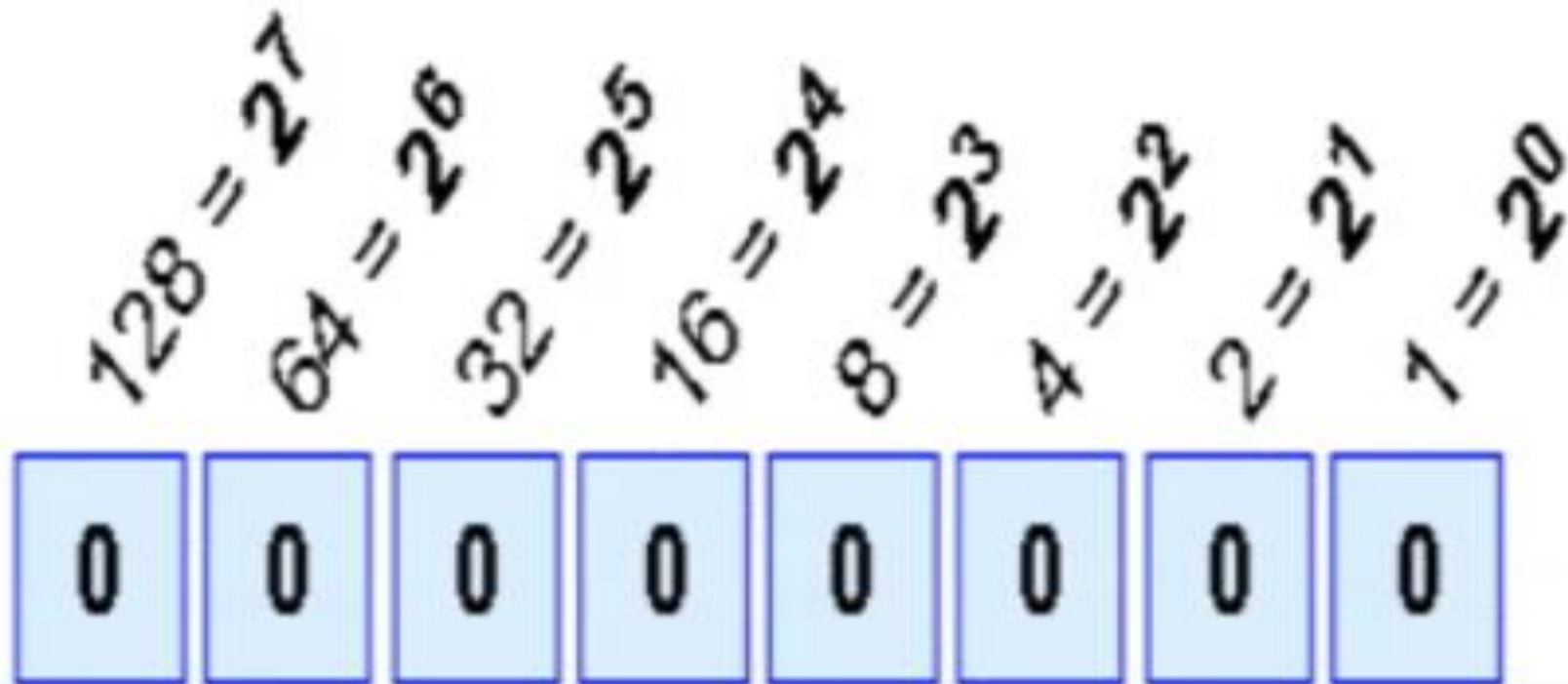
$$\mathbf{111110101011} = \underline{\hspace{2cm}}$$

Show Your Work



Place Values

Remember the Place Value



Place Values

Squeaky Hinge

Appendix

Extra Credit

All Six Cards

1	3	5	7	9	11	13	15
17	19	21	23	25	27	29	31
33	35	37	39	41	43	45	47
49	51	53	55	57	59	61	63

2	3	6	7	10	11	14	15
18	19	22	23	26	27	30	31
34	35	38	39	42	43	46	47
50	51	54	55	58	59	62	63

4	5	6	7	12	13	14	15
20	21	22	23	28	29	30	31
36	37	38	39	44	45	46	47
52	53	54	55	60	61	62	63

8	9	10	11	12	13	14	15
24	25	26	27	28	29	30	31
40	41	42	43	44	45	46	47
56	57	58	59	60	61	62	63

16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

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

Worksheet - Convert From Binary or Decimal

Show Your Work



Convert the Following Binary Numbers:

$$\mathbf{11011} = \underline{27}$$

$$\mathbf{00011011} = \underline{27}$$

$$\mathbf{11101010} = \underline{234}$$

$$\mathbf{01111101} = \underline{125}$$

$$\mathbf{10101011} = \underline{171}$$

$$\mathbf{10101010} = \underline{170}$$

$$16+8+0+2+1$$

$$0+0+0+16+8+0+2+1$$

$$128+64+32+0+8+0+2+0$$

$$0+64+32+16+8+4+0+1$$

$$128+0+32+0+8+0+2+1$$

$$128+0+32+0+8+0+2+0$$

Extra Credit

$$\mathbf{111110101011} = \underline{4011}$$

$$2048+1024+512+256+128+0+32+0+8+0+2+1$$

Bits and Bytes?

- How does a computer count?
- It Uses The Binary (Base 2) number system?

You See the Number 3, The Computer Sees 0011

- Bits, Bytes, Words

$41_{10} = 0010\ 1001$
 $254_{10} = 1111\ 1110$
 $255_{10} = 1111\ 1111$
 $256_{10} = 0001\ 0000\ 0000$
└──────────┘
2 BYTES

BIT
 ↓
 0000 0000 0010 1001
└──────────┘
BYTE = 4 Bits
└──────────┘
WORD = 2 BYTES

↙ Int (Integer) = 2 BYTES

Decimal (Base 10)	Binary (Base 2)	Hex (Base 8)
0	0000 0000	0
1	0000 0001	1
2	0000 0010	2
3	0000 0011	3
4	0000 0100	4
5	0000 0101	5
6	0000 0110	6
7	0000 0111	7
8	0000 1000	8
9	0000 1001	9
10	0000 1010	A
11	0000 1011	B
12	0000 1100	C
13	0000 1101	D
14	0000 1110	E
15	0000 1111	F
16	0001 0000	10

Squeaky Hinge

Sources and References

Source Material & Credits

- Online Magic - http://avimagic.com/tricks/number_cards.php
- Binary Trick - [http://www.mathmaniacs.org/lessons/01-binary/Magic Trick/](http://www.mathmaniacs.org/lessons/01-binary/Magic%20Trick/)
- Work sheet - http://www.cse4k12.org/binary/magic_trick.html
- Magic Binary Cards - [http://www.northeastern.edu/seigen/11Magic/Binary/Magic binary cards.pdf](http://www.northeastern.edu/seigen/11Magic/Binary/Magic_binary_cards.pdf)
- Base 5 Number System – Basics - https://www.youtube.com/watch?v=qGi29E9q_f0
- Binary Number System - <https://www.mathsisfun.com/binary-number-system.html>

Squeaky Hinge

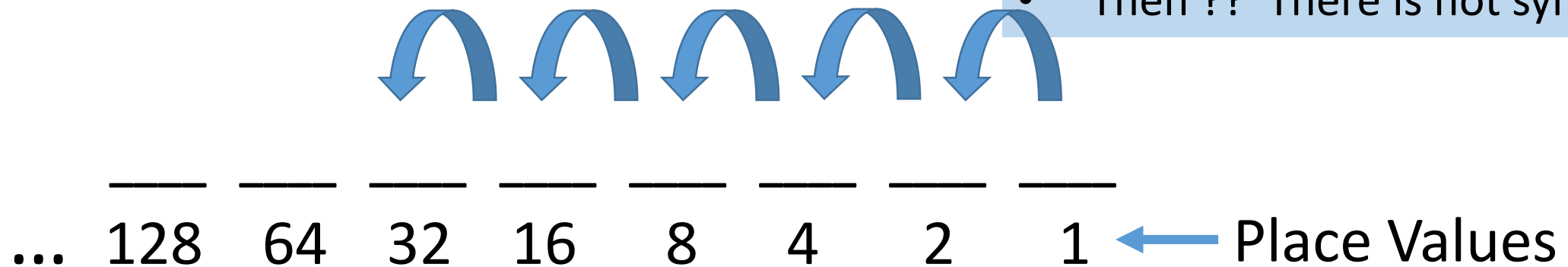
Working Slides

Base 10	Base 2	Place Space
0	0	0 ones
1	1	1 one
2	10	1 two and zero ones
3	11	1 two and 1 one
4	100	1 four, 0 twos, and 0 ones
5	101	1 four, 0 twos, and 1 one
6	110	1 four, 1 two, and 0 ones
7	111	1 four, 1 two, and 1 one
8	1000	1 eight, 0 fours, 0 twos, and 0 ones
9	1001	1 eight, 0 fours, 0 twos, and 1 one
10	1010	1 eight, 0 fours, 1 two, and 0 ones
11	1011	1 eight, 0 fours, 1 two, and 1 one
12	1100	1 eight, 1 four, 0 twos, and 0 ones
13	1101	1 eight, 1 four, 0 twos, and 1 one
14	1110	1 eight, 1 four, 1 two, and 0 ones
15	1111	1 eight, 1 four, 1 two, and 1 one

Counting In Binary

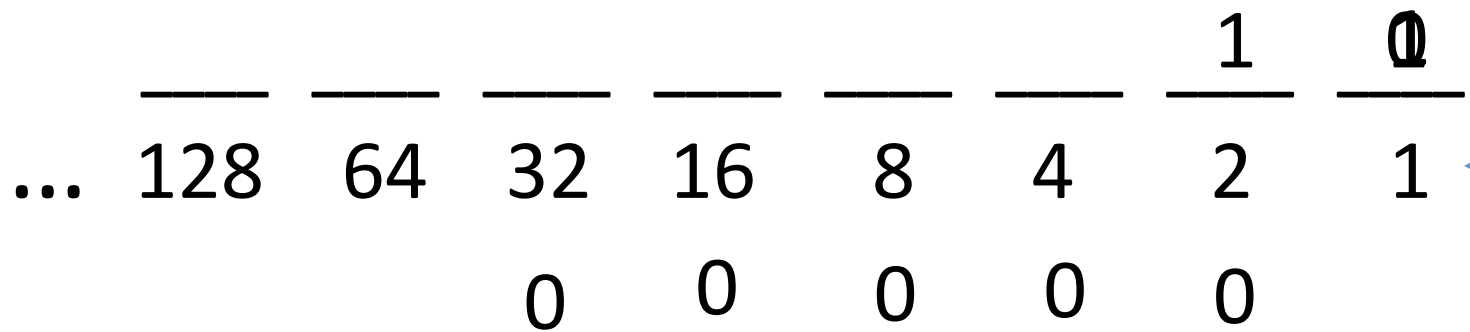
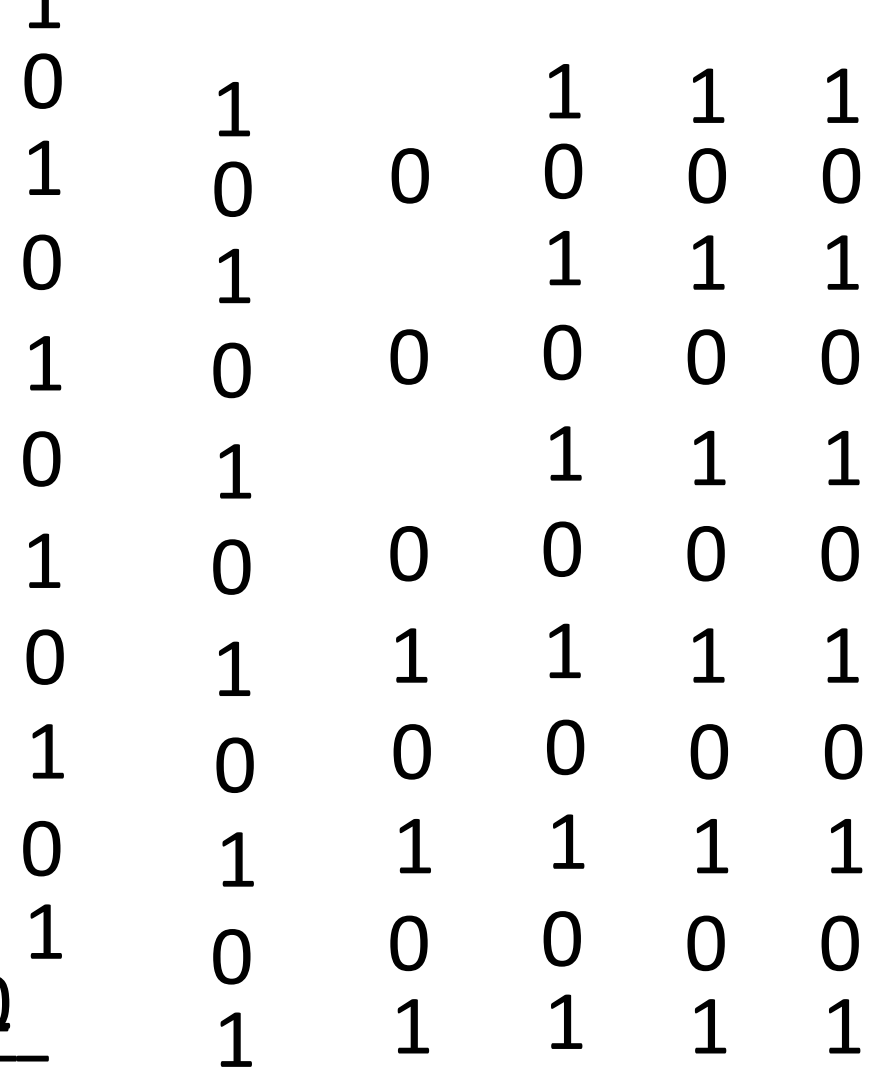
- Remember Binary Numbers are made of **0**s and **1**s
- Here Is An Example Of A Binary Number: **101011**
 - Binary Number can only be made from the Digits **0-1**
 - There is no **2,3,4,5,6,7,8** or **9** in Binary
- Lets Start Counting...

- Start with 0
- Then count to 1
- Then ?? There is not symbol for 2



Counting In Binary

0



← Place Values