Base10 Base2

$1+1=10$

1 + 1 = 10

Decimal (0..9) Binary (0,1)

$$\begin{array}{r} 9 \\ +1 \\ \hline 10 \end{array}$$

Decimal	Binary
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

$$\begin{array}{r} 1 \\ +1 \\ \hline 10 \end{array} \qquad \begin{array}{r} 101 \\ +1 \\ \hline 110 \end{array}$$

$$\begin{array}{r} 10 \\ +1 \\ \hline 11 \end{array} \qquad \begin{array}{r} 110 \\ +1 \\ \hline 111 \end{array}$$

$$\begin{array}{r} 11 \\ +1 \\ \hline 100 \end{array} \qquad \begin{array}{r} 111 \\ +1 \\ \hline 1000 \end{array}$$

$$\begin{array}{r} 100 \\ +1 \\ \hline 101 \end{array}$$

7 0 0 face value

10^3 | 10^2 | 10^1 | 10^0

1000 100 10 1 positional value

$7 \times 100 = 700$

$0 \times 10 = 0$

$0 \times 1 = 0$

$\overline{700}$

1 0 0 1

$1 \times 8 = 8$

$0 \times 4 = 0$

$0 \times 2 = 0$

$1 \times 1 = 1$

$\overline{9}$

1 1 1 1

2^3 2^2 2^1 2^0

8 4 2 1

$1 \times 8 = 8$

$1 \times 4 = 4$

$1 \times 2 = 2$

$1 \times 1 = 1$

$\overline{15}$

$1 \times 4 = 4$

$1 \times 2 = 2$

$1 \times 1 = 1$

$\overline{7}$

$74_{10} = \underline{\ \ }\ \underline{1}\ \underline{0}\ \underline{0}\ \underline{1}\ \underline{0}\ \underline{1}\ \underline{0}_2$

128 64 32 16 8 4 2 1

$$
\begin{array}{r}
74 \\
-64 \\
\hline
10 \\
-8 \\
\hline
2 \\
-2 \\
\hline
0
\end{array}
$$

$\underset{2^6}{\underline{1}}\ \underset{2^5}{\underline{0}}\ \underset{2^4}{\underline{0}}\ \underset{2^3}{\underline{1}}\ \underset{2^2}{\underline{0}}\ \underset{2^1}{\underline{1}}\ \underset{2^0}{\underline{0}}{}_2 = \underline{74}_{10}$

64 32 16 8 4 2 1

$$
\begin{array}{r}
1 \times 64 = 64 \\
1 \times 8 = 8 \\
1 \times 2 = 2 \\
\hline
74_{10}
\end{array}
$$

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$$150_{10} = \underset{128}{1}\;\underset{64}{0}\;\underset{32}{0}\;\underset{16}{1}\;\underset{8}{0}\;\underset{4}{1}\;\underset{2}{1}\;\underset{1}{0}$$

$$\begin{array}{r} 150 \\ -\,128 \\ \hline 22 \\ 16 \\ \hline 6 \\ -\,4 \\ \hline 2 \\ -\,2 \\ \hline 0 \end{array}$$

$$
\begin{array}{rrl}
 & 1\,0\,\,1 & \\
 & 1101 & = 13 \\
 & 8\,4\,2\,1 & \\
 & 110 & = 6 \\
+ & 110 & = 6 \\
\hline
 & 11001 & = 25 \\
 & 16\,8\,4\,2\,1 &
\end{array}
$$

0

1

10

11

100

101

Numbering Systems Assignment

This is an open notes/open book assignment. You need to pass in the work with the answers.

Binary conversion:

111001_2 = ______________ $_{10}$

91_{10} = ______________ $_2$

1010100101_2 = ______________ $_{10}$

356_{10} = ____________________________ $_2$

Binary arithmetic:

```
  100      11111     110111    110101
   11        111       1001    111010
+  11     +11010    +101101   +111111

 1110      10101    1110111    100001
-1010     - 1100    - 11101   - 11111
```

Hexadecimal conversion:

$E8_{16}$ = ______________ $_{10}$

437_{10} = ______________ $_{16}$

$A5CF_{16}$ = ______________ $_{10}$

7825_{10} = ______________ $_{16}$

111000111101_2 = _____________ $_{16}$

```
 10 1 1 1  1
   110101
   111010
 + 111111
 --------
 10101110
```

0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111

$\cancel{1}$ ^{10} (2 ones)

$\quad 0\,1\,0\,0$

$-\ 1\,0\,0\,0$

$\quad 1\,1\,0\,0$

$\quad 1\,0\,1\,0\,0$

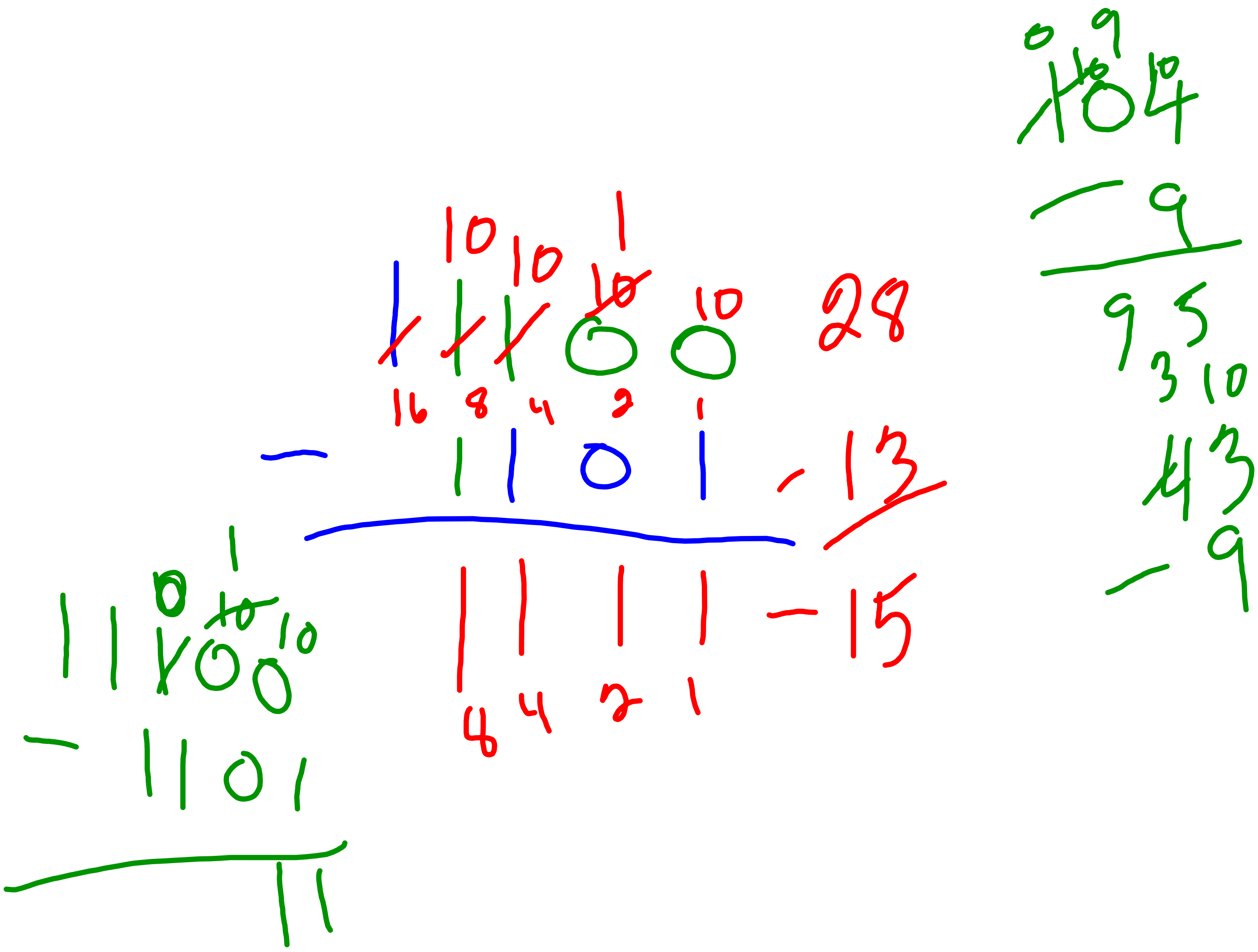
1

$+1$

10

$$\begin{array}{r} 100010 \\ -\quad 101 \\ \hline 1101 \end{array}$$

$$\begin{array}{r} 100 \\ -\quad 1 \\ \hline 11 \end{array}$$



Base 16

(0 - 9

A, B, C, D, E, F

$$
\begin{array}{r}
{}^{1} \\
1F \\
+\ \ 1 \\
\hline
20
\end{array}
\qquad
\begin{array}{r}
{}^{1} \\
FF \\
+\ \ 1 \\
\hline
100
\end{array}
$$

Dec	Hex
0	0
1	
2	
3	
4	
5	
6	
7	
8	
9	9
10	A
11	B
12	C
13	D
14	E
15	F
16	10

Hexadecimal Numbering System:

The next numbering system is the hexadecimal numbering system. This is the base 16 numbering system, therefore there are 16 digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F). The letter A carries the same value as decimal 10, the letter B carries the same value as decimal 11, the letter C carries the same value as decimal 12, the letter D carries the same value as decimal 13, the letter E carries the same value as decimal 14, and the letter F carries the same value as decimal 15. Hexadecimal, like any other numbering system has the face value of digits and the positional value. The positional value is based on the powers of 16 since hexadecimal is the base 16 numbering system.

Example: Hexadecimal number A359

A	3	5	9	face value
16^3	16^2	16^1	16^0	positional value (powers of 16)
4096	256	16	1	resolved positional value

Converting hexadecimal to decimal:
To convert hexadecimal to its decimal equivalent, we multiply the face value times the positional value:

A x 16^3 =	10 x 4096 =	40960	(note A is equivalent to decimal 10)
3 x 16^2 =	3 x 256 =	768	
5 x 16^1 =	5 x 16 =	80	
9 x 16^0 =	9 x 1 =	9	
		41817	

The equivalent of hexadecimal A359 in decimal is 41817.

Converting decimal to hexadecimal:

Now we will take the decimal number 41817 and convert it back to hexadecimal. To do this, we will follow the same steps we used in converting decimal to binary with one change Ð this time we are concerned with multiplying by the face value (in binary this was not a concern because multiplying by 1 doesnÕt change anything).

The following are the decimal equivalents for some of the commonly used powers of 16:

$16^0 = 1$ $16^1 = 16$ $16^2 = 256$ $16^3 = 4096$ $16^4 = 65536$

The following steps convert decimal 41817 to hexadecimal:

1. First we need to find out the highest base of 16 that can be subtracted from our number, 41817. Clearly 16 to the 4th which is equivalent to 65536 is too big. However, 16 to the 3rd which is equivalent to 4096 will work. Our next question is how many 16 to the 3rd s can be subtracted from 41817. Through trying different calculations, we discover that 10 x 4096 or 40960 is the most powers of 16 to the 3rd that we can subtract so we place A (the equivalent of 10) in the 16 to the 3rd position.

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   We subtract: 41817 Ð 40960 = 857

A	_____	_____	_____
16^3	16^2	16^1	16^0
4096	256	16	1

2. Now, we have established the first power of 16 that we can use. We now move over to 16 to the 2nd power which has the equivalent of 256 and ask how many times can 256 be subtracted from 857. Again, we try the calculations and discover 3 256s (768) can be subtracted from 857 which means we enter a 3 in the 16 to the 2nd position.
   We subtract: 857-768 = 89

A	3	_____	_____
16^3	16^2	16^1	16^0
4096	256	16	1

3. Now we have 89 left. Looking at 16 to the 1st with the equivalent of 16, we ask how many 16s can be subtracted from 89. The answer is 5 (16 x 5 = 80), so we place a 5 in the 16 to the 1st position.
   We subtract: 89 Ð 80 = 9

A	3	5	_____
16^3	16^2	16^1	16^0
4096	256	16	1

4. Now we have 9 left. There is only the 16 to the 0th position with the equivalent value of 1 left. Clearly if we subtract 9 x 1 from 9 we will have 0 left and that is our goal, so we place a 9 in the 16 to the 0th position.
   We subtract: 9-9=0

A	3	5	9
16^3	16^2	16^1	16^0

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16^3	16^2	16^1	16^0	positional value (powers of 16)
4096	256	16	1	resolved positional value

A 3 5 9 face

16^3 16^2 16^1 16^0 16 position

4096 256 16 1

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To convert hexadecimal to its decimal equivalent, we multiply the face value times the positional value:

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		41817	

The equivalent of hexadecimal A359 in decimal is 41817.

10 x 4096 = 40960

3 x 256 = 768

5 x 16 = 80

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41817_{10}

Converting decimal to hexadecimal:

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$41817_{10} = \underline{\quad\quad}_{16}$

how many

$$
\begin{array}{r}
41817 \\
-40960 \\
\hline
857 \\
-768 \\
\hline
89 \\
-80 \\
\hline
9
\end{array}
$$

10

4096

A	3	5	9
16^3	16^2	16^1	16^0
4096	256	16	1

$9 - 9 = 0$