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## Number Systems

Unsigned Numbers:

Binary (base 2)

digit weighting  $\frac{1}{2^3} \frac{0}{2^2} \frac{1}{2^1} \frac{0}{2^0} . \frac{1}{2^{-1}} \frac{0}{2^{-2}} \frac{1}{2^{-3}}$

$$\text{value} \Rightarrow 8 + 2 + 0.5 + 0.125 = 10.625$$

Octal (base 8)

digit weighting  $\frac{1}{8^4} \frac{7}{8^3} \frac{5}{8^2} \frac{3}{8^1} \frac{2}{8^0} . \frac{7}{8^{-1}} \frac{6}{8^{-2}} \frac{5}{8^{-3}}$

value  $\Rightarrow$

Hex (base 16)

Decimal Hex digit wt.  $\frac{1}{16^4} \frac{E}{16^3} \frac{4}{16^2} \frac{D}{16^1} \frac{A}{16^0} . \frac{C}{16^{-1}} \frac{9}{16^{-2}} \frac{F}{16^{-3}}$

1-9 1-9

10 A

11 B value  $\Rightarrow$

12 C

13 D

14 E

15 F

16 10

# Number Systems

## Unsigned Numbers, Conversions:

### Octal to Binary

753.172<sub>8</sub>  
↓ ↓ ↓ ↓ ↓ ↓  
111 101 011 . 001111 010<sub>2</sub>

### Hex to Binary

E03B.A1C<sub>16</sub>  
↓ ↓ ↓ ↓ ↓ ↓ ↓  
1110 0000 0011 1011 . 1010 0001 1100<sub>2</sub>

Octal to Hex  
via Binary  
representation

### Binary to Hex (groups of 4 bits)

111101011 . 001111010<sub>2</sub>  
↓ ↓ ↓ ↓ ↓ ↓  
1 E B . 3 D<sub>16</sub>

### Binary to Octal (groups of 3 bits)

1110000000111011 . 101000011100  
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓  
1 6 0 0 7 3 . 5 0 3 4

Hex to Octal  
can quickly be done  
via Hex → Binary → Octal

# Number Systems

## Unsigned Number Addition:

$$\begin{array}{r}
 \text{Octal} \quad \begin{array}{cccc} 1 & 1 & 1 & 1 \\ 1 & 5 & 7 & . & 7 & 5 & 3 \end{array} \text{ carry} \\
 + \quad \underline{366.046_8} \\
 546.021_8
 \end{array}$$

$$\begin{array}{r}
 \text{Hex} \quad \begin{array}{r} 157.753_{16} \\ + 366.046_{16} \\ \hline 4BD.799_{16} \end{array}
 \end{array}$$

| Decimal | Hex |
|---------|-----|
| 10      | A   |
| 11      | B   |
| 12      | C   |
| 13      | D   |
| 14      | E   |
| 15      | F   |

$$\begin{array}{r}
 \text{Binary} \quad \begin{array}{r} \begin{array}{cccc} 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \end{array} \text{ carry} \\ 1011.011_2 \\ + 0101.101_2 \\ \hline 10001.000_2 \end{array}
 \end{array}$$

$$\begin{array}{r}
 \begin{array}{r} \begin{array}{cccc} 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{array} \\ 01111.111_2 \\ + 00000.001_2 \\ \hline 10000.000_2 \end{array}
 \end{array}$$

$$\begin{array}{r}
 10110.111 \\
 + 10001.01 \\
 \hline
 ?
 \end{array}$$

$$\begin{array}{r}
 \text{Hex} \quad \begin{array}{r} \begin{array}{cccc} 1 & 1 & 1 & 1 \\ A & B & C & D \end{array} \\ ABCD.5EF_{16} \\ + 61E3.FC0_{16} \\ \hline 10DB1.5AF_{16} \end{array}
 \end{array}$$

$$\begin{array}{r}
 \text{Decimal} \\
 + E \quad 14 \\
 + C \quad 12 \\
 \hline
 26 - 16 = 10 \quad \left. \begin{array}{l} \text{carry} = 1 \\ \text{Remainder} = 10 \text{ or } A_{16} \end{array} \right\}
 \end{array}$$

# Number Systems

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## Unsigned Numbers, Multiplication:

Octal & Hex } easiest to convert to decimal then multiply out  
& convert back

Binary

$1011.11_2$

$\times 10.001_2$

$1.01111$  (original shifted down 3 places)

$10111.10000$  (original shifted up 3 places)

add

$11000.11111_2$

Binary

$1100.101$

$(12.625_{10})$

$\times$

$111.110$

$(7.75_{10})$

$= 97.84375$

$2 \ 11.00101$

$2 \ 110.01010$

$2 \ 1100.10100$

$2 \ 11001.01000$

$110010.10000$

$1100001.11011$

$\underbrace{\hspace{1cm}} \underbrace{\hspace{1cm}}$

$1100001 + 1$



$97.84375$  correct!