

Number Bases

- 1) All numbers represent a value
- 2) Base (or Radix) defines range of digit values
- 3) Each position carries a weight which is a power of the base

What value is represented by the following number?

10

Base (or Radix) defines range of digit values

Base	Values
Base 10 (decimal)	0,1,2,3,4,5,6,7,8,9
Base 2 (binary)	0,1
Base 8 (octal)	0,1,2,3,4,5,6,7
Base 16 (hexadecimal)	0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

Each position carries a weight which is
a power of the base

$$\begin{aligned} &549_{10} \\ &= 5 \times 10^2 + 4 \times 10^1 + 9 \times 10^0 \\ &= 500 + 40 + 9 \\ &= 549_{10} \end{aligned}$$

Each position carries a weight which is
a power of the base

$$\begin{aligned} &1010_2 \\ &= 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 \\ &= 8 + 0 + 2 + 0 \\ &= 10_{10} \end{aligned}$$

Each position carries a weight which is
a power of the base

$$\begin{aligned} 34_8 &= 3 \times 8^1 + 4 \times 8^0 \\ &= 24 + 4 \\ &= 28_{10} \end{aligned}$$

Each position carries a weight which is
a power of the base

$$\begin{aligned} &13_{16} \\ &= 1 \times 16^1 + 3 \times 16^0 \\ &= 16 + 3 \\ &= 19_{10} \end{aligned}$$

Each position carries a weight which is
a power of the base

**Exercise: Convert each number to a DECIMAL
value:**

11111_2

0101_2

132_8

123_{16}

Powers of 2

1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024...

Exercise: Convert each number to a DECIMAL value:

1010101_2

101101_2

Fractions

$$1111.111_2$$
$$= 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3}$$

Exercise: What value is represented by the following number?

$$10101.01_2$$

Decimal to any Number Base

Divide by Number Base

Example:

35 to Binary

35 to Octal

Octal

BINARY TO OCTAL

- form groups of 3 bits starting from the right.
- Pad on left with zeroes (if needed)
- convert each group to an actual digit

Examples: 110101011011_2

OCTAL TO BINARY

- convert each digit to 3 bit binary
- concatenate

Examples: 735_8

EXERCISES:

Convert to Binary: 45132_8

Convert to Octal: 101110110_2
 10110110_2

Binary	Octal
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

Hexadecimal

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

BINARY TO HEXADECIMAL

- form groups of 4 bits starting from the right.
- Pad on left with zeroes (if needed)
- convert each group to an actual digit

Examples: 110101011011_2

HEXADECIMAL TO BINARY

- convert each digit to 4 bit binary
- concatenate

Examples: 735_{16}

EXERCISES:

Convert to Binary: 45132_{16}

Convert to Hexadecimal: 101110110_2
 10110110_2

Generalizations

- **n bits** - 2^n combinations of 0's and 1's
- number our bits 0 to n-1 from right to left
- Range of n bits = 0 to $2^n - 1$

Binary N bits	Binary	Decimal
4 bits	0000 ₂	0 ₁₀
	1111 ₂	15 ₁₀
8 bits	00000000 ₂	0 ₁₀
	11111111 ₂	255 ₁₀