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

549_{10}

$= 5 \times 10^2 + 4 \times 10^1 \times 9 \times 10^0$

$= 500 + 40 + 9$

$= 549_{10}$

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

1010_2

$= 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 \times 0 \times 2^0$

$= 8 + 0 + 2 + 0$

$= 10_{10}$

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

34_8

$= 3 \times 8^1 + 4 \times 8^0$

$= 24 + 4$

$= 28_{10}$

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

13_8
$= 1 \times 16^1 + 3 \times 16^0$
$= 16 + 3$
$= 19_{10}$

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

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

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

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

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** - 2n 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}