Representing Numbers

Module 1

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Key Takeaways

CONVERSION TABLE

Table containing first 16 binary, decimal, and hex numbers

DECIMAL <--> BINARY

Divide-by-2 & Expansion

DECIMAL <--> HEX

Divide-by-16 & Expansion

HEX <--> BINARY

Reference & 4-Bit Groups

FRACTIONS

Multiply-by-2

CONVERSION TABLE

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

WHAT TO KNOW?

1. Get very familiar with these conversions
2. Practice writing the first 8 or 16 binary numbers…you will do this a lot

DECIMAL ---> BINARY

Divide – by – 2

1. Divide decimal number by 2
2. If a remainder exists, write a 1 – Otherwise, write a 0
3. Discard the remainder
4. Repeat until you reach zero
5. Result is read bottom to top

BINARY ---> DECIMAL

Expansion

1. Each digit represents a specific power of 2
2. Multiple the digit by its associated power of 2
3. Add all of the products together

DECIMAL ---> HEX

Divide – by – 16

1. Divide decimal number by 16
2. Multiple remainder (it will be a fraction) by 16 and write the corresponding Hex digit
3. Discard the remainder
4. Repeat until you reach zero
5. Result is read bottom to top

HEX ---> DECIMAL

Expansion

1. Each digit represents a specific power of 16
2. Multiple the digit by its associated power of 16
3. Add all of the products together

HEX ---> BINARY

Reference Table/Memory

1. Treat each hex digit separately
2. Convert each digit to a 4-Bit binary number from reference or memory
3. Combine them (maintain their order)

BINARY ---> HEX

4-Bit Groups

1. Pad the binary number on the left side until the number of bits is divisible by 4
2. Separate the number into 4-Bit groups
3. Convert each group into a Hex digit from reference or memory
4. Combine them (maintain their order)

DECIMAL ---> BINARY

Multiply – by – 2

1. Convert whole portion as usual (divide – by – 2)
2. Multiple fractional part by 2
3. If product is >= 1, write a 1 – Otherwise write a 0
4. Discard any whole portion and repeat steps on fractional part
5. Stop at 0 or at sufficient precision
6. Result is read top to bottom

DON'T FORGET!

1. When dealing with fractions, you must read the answer from top to bottom
2. n bits can represent 2^n different numbers and the range of those numbers is 0 to $2^n - 1$

Practice Problems Conversions

1. Convert **$1AD5_{16}$** to Decimal
2. Convert **$BE101_{16}$** to Binary
3. Convert **01001101011_{2}** to Decimal
4. Convert **11101100001_{2}** to Hex
5. Convert **2345** to Hex
6. Convert **456** to Binary
7. Convert **0.46** to Binary
8. Convert **8.945** to Binary

Practice Problems Conceptual

9. Why do we need to “pad” binary numbers with 0s when converting to Hex?
10. Can we convert from binary to decimal using the 4-Bit Grouping method? Why or why not?
11. How many different numbers can be represented with 4 bits?
12. How many bits would you need to account for 17 numbers?

Practice Problems Answers

1. $1AD5_{16}$ = **6869**
2. $BE101_{16}$ = **$1011111000010000000 1_2$**
3. 01001101011_2 = **619**
4. 11101100001_2 = **761_{16}**
5. 2345 = **929_{16}**
6. 456 = **111001000_2**
7. 0.46 = **0.01110101110_2**
8. 8.945 = **1000.1111000111_2**
9. As we separate the groups of binary digits (starting at the right), we may end up with less than 4 digits on the left side. We add extra 0s so that we can reference the Hex digits, which require 4 binary digits.
10. No, we can't. The fact that 16 (Hex) is a power of 2 makes the direct conversion possible. 10 (Decimal) is not a power of 2 and thus we can't convert directly.
11. 16 States with a range of 0-15.
12. 17 is 1 more than we can represent with 4 bits, so we need to use an extra bit. Thus, we need 5 bits.