

Integer Numbering Systems

Learning Objectives

1. Convert an integer from one base to another.
2. Count to 16 in binary.
3. Convert a binary number to any power of 2 base (4, 8, 16, 32, etc...)
4. Determine number of bits necessary to represent a number.

Numbering Systems

List examples of each type of numbering system

Unary

Grouping

Positional

Positional Number System

Equation

$$\text{number} = \sum$$

$$d = \underline{\hspace{2cm}} \quad b = \underline{\hspace{2cm}} \quad n = \underline{\hspace{2cm}}$$

Example

$$1832 = (2 * \underline{\hspace{1cm}} + 3 * \underline{\hspace{1cm}} + 8 * \underline{\hspace{1cm}} + 1 * \underline{\hspace{1cm}})$$

Octal: Base ____*Digits*

There are _____ digits in octal. They are:

Example

Convert 345_8 to decimal

$$345_8 = (5 * \underline{\hspace{2cm}} + 4 * \underline{\hspace{2cm}} + 3 * \underline{\hspace{2cm}})_{10} = \\ =$$

Convert 1001_8 to decimal

Syntax in C

Prefix number with 0: e.g. 76_8 in C is written as: _____

Hexadecimal: Base ____*Digits*

There are _____ digits in hexadecimal. They are:

List the hexadecimal digits:

Syntax in C

Prefix number with 0x: e.g. 76_{16} in C is written as: _____

Example

Convert $0xA3$ to decimal

$$0xA3 = (3 * \underline{\hspace{2cm}} + A * \underline{\hspace{2cm}}) = \underline{\hspace{2cm}}$$

Convert $0x3E8$ to decimal

$$0x3E8 = \underline{\hspace{2cm}}$$

Binary: Base 2

Digits

There are _____ digits in binary.

List the binary digits:

A single binary digit is called a _____

A group of 8 bits is called a _____

A group of 4 bits is called a _____

Example

Convert 1001_2 to decimal:

Convert 1101_2 to decimal:

Count

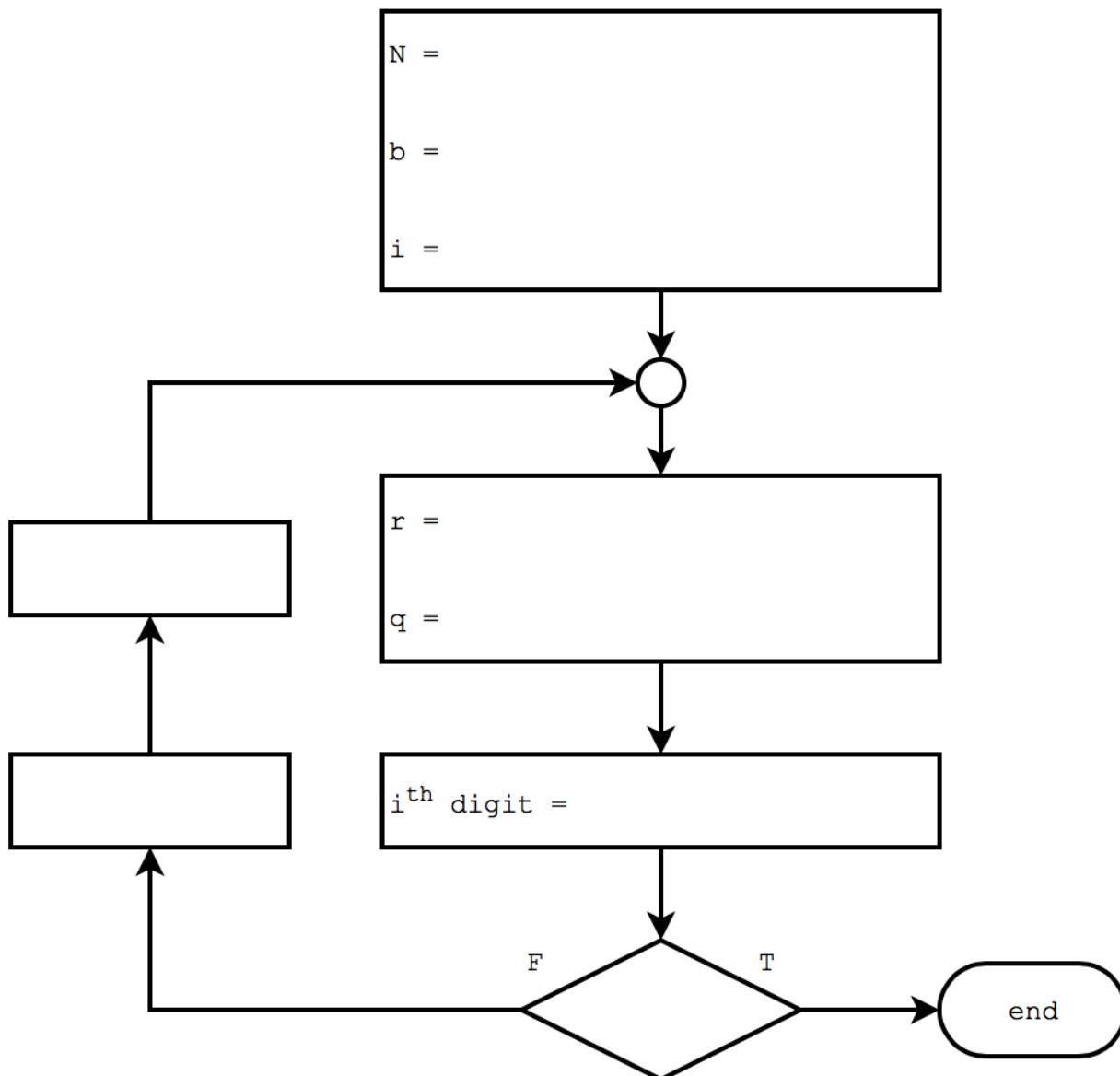
Decimal	Hexadecimal	Octal	Binary
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Note

"10" in any base system is equal to the value of the _____

0x10 =	10 ₈ =	10 ₂ =
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Conversion From Decimal



Example

Convert 28_{10} to octal (base 8)	i = 1 ----- N = r = q = Does q = 0?
i: <u>4</u> <u>3</u> <u>2</u> <u>1</u> <u>0</u>	i = 2 ----- N = q = r = Does q = 0?

Example

Convert 35_{10} to base 5	i = 1 ----- N = r = q = Does q = 0?
i: <u>4</u> <u>3</u> <u>2</u> <u>1</u> <u>0</u>	i = 2 ----- N = r = q = Does q = 0?

Conversion decimal to binary

Know your powers of 2!!

2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}
1	2											

2^{10}	2^{20}	2^{30}	2^{40}

Examples

Convert 444_{10} to binary

Common non-decimal bases

Easy binary conversions

Some numbering systems are easy to convert to and from binary:

Binary <-> Octal

When converting binary to octal, separate bits in groups of _____

Example

Convert 101111_2 to octal = _____	Convert 31_8 to binary 3 1 = _____
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What happens if the number of binary digits are not divisible by _____?

Example

Convert 11001101_2 to octal	Convert 175_8 to binary
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Binary <-> Hexadecimal

When converting binary to hexadecimal, separate bits in groups of _____

Example

Convert 11011011_2 to hexadecimal = _____	Convert $0xBB8$ to binary
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What happens if the number of binary digits are not divisible by _____?

Example

Convert $01100000011111111101110_2$, to hexadecimal

Convert 10010001101000_2 to hexadecimal

Octal <-> Hexadecimal

First convert to _____, then to _____.

Example

Convert 0xC3B0 to octal

Convert 111_8 to hexadecimal

Representing Multi-Bit Values

MSB:

LSB:

Example

X = 0101001101010101

bit # _____

$x = 0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1$

$$X[14:9] = \quad \quad \quad X[2:0] =$$

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Example: R-type MIPS Instruction

op	rs	rt	rd	shamt	funct
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Largest Number

What is the largest number we can represent in n digits?

Example

What is the largest decimal number we can represent with 5 decimal digits?

This is also equal to :

What is the largest number we can represent with 5 bits?

How many bits are necessary?

Logarithm Review

$$a^b = c \Rightarrow \log_2 x \equiv$$

bit to represent an integer n = _____

Example

How many bits are needed to represent the number 444_{10} ?

How many bits are needed to represent the number 789_{10} ?

How many bits are needed to represent the number 1500_{10} ?