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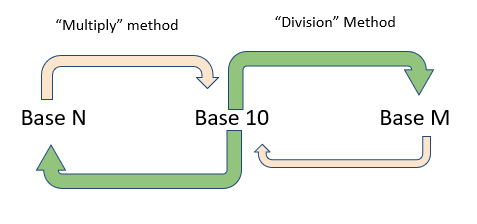
# Objective

* Learn how numbers can be represented in different ways and bases, converting from between them is also known as **Change of Bases**.

# Purpose

* Computers only read binaries (Base 2).
* Understand how number can be represented in different bases
* Learn to convert between bases

# Introduction



## Base 10

* 10 alias to represent numbers starting from 0 to 9
* 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

## Base 2 (Binary)

* 2 alias to represent numbers starting from 0 to 1
* 0, 1

## Base 8 (Octal)

* 8 alias to represent numbers starting from 0 to 7
* 0, 1, 2, 3, 4, 5, 6, 7

## Base 16 (Hexadecimal)

* 16 alias to represent numbers starting from 0 to 9, A to F
* 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

# Convert Base N to Base 10 (Multiply method)

## Example 1 – converting from Base 2 to Base 10

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Base 2 | 0 | 1 | 1 | 0 | 0 |
| Power | 24 | 23 | 22 | 21 | 20 |
| Multiply | 0 \* 24 | 1 \* 23 | 1 \* 22 | 0 \* 21 | 0 \* 20 |
| Calculate | 0 | 8 | 4 | 0 | 0 |
| Add | 0 + 8 + 4 + 0 + 0 | | | | |
| Base 10 | 12 | | | | |

## Example 2 – converting from Base 3 to Base 10

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Base 2 | 1 | 0 | 1 | 2 | 2 |
| Power | 34 | 33 | 32 | 31 | 30 |
| Multiply | 1 \* 34 | 0 \* 33 | 1 \* 32 | 2 \* 31 | 2 \* 30 |
| Calculate | 81 | 0 | 9 | 6 | 2 |
| Add | 81 + 0 + 9 + 6 + 2 | | | | |
| Base 10 | 98 | | | | |

## Example 3 – converting from Base 16 to Base 10

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Base 2 | A | C | 9 | 5 | 3 |
| Power | 164 | 163 | 162 | 161 | 160 |
| Multiply | 10 \* 164 | 12 \* 163 | 9 \* 162 | 5 \* 161 | 3 \* 160 |
| Calculate | 10 \* 65536 = 655360 | 12 \* 4096 = 49152 | 9 \* 256 = 2304 | 80 | 3 |
| Add | 655360 + 49152 + 2304 + 80 + 3 | | | | |
| Base 10 | 706899 | | | | |

# Convert Base 10 to Base N (Division Method)

## Example 1 – converting Base 10 to Base 2

2 | 14 | Remainder  
| 7 | 0 (7 >= 2, continue)  
| 3 | 1 (3 >= 2, continue)  
| 1 | 1 (1 < 2, stop)  
| 1

Base 2 = 1110 (read from bottom up)

## Example 2 – convert base 10 to base 16

16 | 666 | Remainder  
| 41 | 10 (41 >= 16, continue)  
| 2 | 9 (2 < 16, stop)  
| 2   
Base 16 = 29A (read from bottom up)

# Tips

## Base 16 (HEX) to Base 2 (BIN), vice versa (“4-bit partition method”)

## Example – Convert 0xAD3EF23750F

## A D 3 E F 2 3 7 5 0 F

1010\_1101\_0011\_1110\_1111\_0010\_0011\_0111\_0101\_0000\_1111

## Base 8 (OCT) to Base 2 (BIN), vice versa (“3-bit partition method”)

## Convert 075643742153

7 5 6 4 3 7 4 2 1 5 3

111\_101\_110\_100\_011\_111\_100\_010\_001\_101\_011

# Bit Conversion - Questions

Convert the following from its respective bases

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Question | Bin (Base 2) | Oct (Base 8) | Dec (Base 10) | Hex (Base 16) |
| 1102 |  |  |  |  |
| 110112 |  |  |  |  |
| 1010012 |  |  |  |  |
| 1011012 |  |  |  |  |
| 1768 |  |  |  |  |
| 228 |  |  |  |  |
| 4418 |  |  |  |  |
| 2448 |  |  |  |  |
| 5010 |  |  |  |  |
| 66610 |  |  |  |  |
| 33310 |  |  |  |  |
| 43410 |  |  |  |  |
| 4418 |  |  |  |  |
| 0xAB16 |  |  |  |  |
| 0x12316 |  |  |  |  |
| 0x2F16 |  |  |  |  |
| 0x1316 |  |  |  |  |
| 0xA2C16 |  |  |  |  |
| 0xFFF16 |  |  |  |  |

Operations

|  |  |
| --- | --- |
| 1011012+ 1110112 |  |
| 1100002- 001112 |  |
| 1111112\* 1012 |  |
| 1111112/1112 |  |
| 0x12316+0xABC16 |  |
| 0xABC16-0x89116 |  |
| 0xB16\*0x216 |  |
| 0x1416/0xA16 |  |

Convert to Base 10 OR evaluate the expressions

|  |  |
| --- | --- |
| 35.26 | Base 10 = |
| 11.38 | Base 10 = |
| 11.529 | Base 10 = |
| 33.38-11.18 |  |
| 111.1112 | Base 10 = |

# Bit Conversion - Answers

Convert the following from its respective bases

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Question | Bin | Oct | Dec | Hex |
| 1102 | 110 | 6 | 6 | 6 |
| 110112 | 11011 | 33 | 27 | 1B |
| 1010012 | 101001 | 51 | 41 | 29 |
| 1011012 | 101101 | 55 | 25 | 2D |
| 1768 | 1111110 | 176 | 126 | 7E |
| 228 | 10010 | 22 | 18 | 12 |
| 4418 | 100100001 | 441 | 289 | 121 |
| 2448 | 10100100 | 244 | 164 | A4 |
| 5010 | 110010 | 62 | 50 | 32 |
| 66610 | 1010011010 | 1232 | 666 | 29A |
| 33310 | 101001101 | 515 | 333 | 14D |
| 43410 | 110110010 | 662 | 434 | 1B2 |
| 4418 | 100100001 | 441 | 289 | 121 |
| 0xAB16 | 10101011 | 253 | 171 | 0xAB |
| 0x12316 | 100100011 | 443 | 291 | 0x123 |
| 0x2F16 | 101111 | 57 | 47 | 0x2D |
| 0x1316 | 10011 | 23 | 19 | 0x13 |
| 0xA2C16 | 101000101100 | 5054 | 2604 | 0xA2C |
| 0xFFF16 | 111111111111 | 7777 | 4095 | 0xFFF |

Operations

|  |  |
| --- | --- |
| 1011012+ 1110112 | 10010002 |
| 1100002- 001112 | 1010012 |
| 1111112\* 1012 | 1001110112 |
| 1111112/1112 | 10012 |
| 0x12316+0xABC16 | 0xBDF16 |
| 0xABC16-0x89116 | 0x22B16 |
| 0xB16\*0x216 | 0x1616 |
| 0x1416/0xA16 | 0x216 |

Convert to Base 10 OR evaluate the expressions

|  |  |
| --- | --- |
| 35.26 | Base 10 = 24/3 |
| 11.38 | Base 10 = 2/3 |
| 11.529 | Base 10 = 57/81 |
| 33.38-11.18 | 22.28 |
| 111.1112 | Base 10 = 14/8 |