Exploring Computer Science Concepts

Via ACSL Competitions

Number Systems

- Decimal
  - base 10
- Binary
  - base 2
- Octal
  - base 8
- HexaDecimal
  - base 16

Digits per base

- Decimal
  - Ten digits
  - 0 1 2 3 4 5 6 7 8 9
- Binary
  - Two Digits
  - 0 1
- Octal
  - 8 digits
  - 0 1 2 3 4 5 6 7
- Hexadecimal
  - 16 digits
  - 0 1 2 3 4 5 6 7 8 9 A B C D E F

Counting in Decimal

- Increment the lowest place value (right most digit)
- When last digit is reached
  - Set the current column to 0
  - Increment the column on the left by 1
- Lets count with decimal
  - 0 to 10
  - 95 to105
- How frequently do we add a new digit ?

Decimal	Decimal
0	95
1	96
2	97
3	98
4	99
5	100
6	101
7	102
8	103
9	104
10	105

Counting in other bases

- Counting in binary
  - We add a new digit frequently
    - At 2 , 4, 8, 16 … decimal values
- Counting in Octal
  - We add a new digit at every
    - At 8, 64,128 …
- Counting in HexaDecimal
  - We add a new digit at every
    - At 16, 256 … values

Decimal	Binary	Octal	HexaDecimal
0	0	0	1
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10000	20	10

Place Values

- Decimal
  - *We deal in power of 10s*
  - 2452 = 2 * 1000 + 4 * 100 + 5 * 10 + 2 * 1
  - 101 = 1 * 100 + 0 * 10 + 1 * 1
- Binary
  - *We deal in power of 2s*
  - 111 = 1 * 4 + 1 * 2 + 1 * 1
  - 1010 = 1 * 8 + 0 * 4 + 1 * 2 + 0 * 1

Place values
Converting binary →decimal

Decimal	Binary
2452 → 2 x 10^3 = 2000 4 x 10^2 = 400 5 x 10^1 = 50 2 x 10^0 = 2 = 2452	111 → 1 x 2^2 = 1 x 4 = 4 1 x 2^1 = 1 x 2 = 2 1 x 2^0 = 1 x 1 = 1 = 7
101 → 1 x 10^2 = 100 0 x 10^1 = 0 1 x 10^0 = 1 = 101	1010 → 1 x 2^ 3 = 1 x 8 = 8 0 x 2^ 2 = 0 x 4 = 0 1 x 2^ 1 = 0 x 2 = 2 0 x 2^ 0 = 0 x 1 = 0 = 10
756 →	1000 →

Converting Binary to Decimal

128	64	32	16	8	4	2	1	
	1	0	0	1	0	0	1	= 64 + 16 + 1 = 81
1	0	0	0	0	1	1	1	= 128 + 4 + 2 + 1 = 135
1	1	1	0	0	0	0	0	= ?

Converting Decimal to Binary

128 64 32 16 8 4 2 1

= 22

= 33

= 130

Exercises

- Convert following Decimal numbers to binary
  - 127_{10}
  - 128_{10}
  - 129_{10}
  - 255_{10}
  - 256_{10}
- Convert following Binary numbers to Decimal
  - 101101_2
  - 1110_2
  - 1111_2
  - 0110_2

Challenge

- How does binary addition and subtraction work ?

Place values
Converting octal,hexadecimal→decimal

Octal → Decimal	HexaDecimal → Decimal
777 → 7 x 8^2 = 7 x 64 = 448 7 x 8^1 = 7 x 8 = 56 7 x 8^0 = 7 x 1 = 7 = 511	2AB → 2 x 16^2 = 2 x 256 = 512 A x 16^1 = 10 x 16 = 160 B x 16^0 = 11 x 1 = 11 = 683
137 → 1 x 8^2 = 1 x 64 = 64 3 x 8^1 = 3 x 8 = 24 7 x 8^0 = 7 x 1 = 7 = 95	101 → 1 x 16^2 = 1 x 256 = 256 0 x 16^1 = 0 x 16 = 0 1 x 16^0 = 1 x 1 = 1 = 257
756 →	4A3 →

Converting Decimal to Octal

$(312)_{10}$ → $(?)_8$

312 / 8 → quotient : 39 , Remainder 0

39 / 8 → quotient : 4 , Remainder 7

4 / 8 → quotient : 0 , Remainder 4

$\mathbf{(470)_8}$

$(112)_{10}$ →$(?)_8$

112 / 8 → quotient : 14 , Remainder 0

14 / 8 → quotient : 1 , Remainder 6

1 / 8 → quotient : 0 , Remainder 1

$\mathbf{(160)_8}$

Exercises

- Convert following Decimal numbers to Octal
  - 111_{10}
  - 88_{10}
  - 511_{10}
  - 512_{10}
  - 513_{10}
- Convert following Octal numbers to Decimal
  - 45_{8}
  - 77_{8}
  - 100_{8}
  - 101_{8}

Converting Decimal to Hexadecimal

$(312)_{10}$ → $(?)_8$

312 / 16 → quotient : 19 , Remainder 8

19 / 16 → quotient : 1 , Remainder 3

1 / 16 → quotient : 0 , Remainder 1

$\mathbf{(138)_{16}}$

$(112)_{10}$ →$(?)_8$

112 / 16 → quotient : 7 , Remainder 0

7 / 16 → quotient : 0 , Remainder 7

$\mathbf{(70)_{16}}$

Hexadecimal → Octal

$(AC)_{16}$ → $(\mathbf{1010})_2$ x 16 + $(\mathbf{1100})_2$ x 1 //Replace hexa with binary

→ $(\mathbf{1010\ 1100})_2$ // Convert to binary

→ $(\mathbf{010\ 101\ 100})_2$ // group by 3s , added extra 0s in the front

→ ($\mathbf{254}$)$_8$// Replace each group by octal value

$(1EF)_{16}$ → $(\mathbf{0001})_2$ x 256 + $(\mathbf{1110})_2$ x 16 + (1111) x 1

→ $(0001\ 1110\ 1111)_2$ // Convert to binary

→ $(\sout{000}\ 111\ 101\ 111)_2$ // group by 3 , removed 0s in the front

→ ($\mathbf{757}$)$_8$// Replace each group by octal value

Octal → Hexadecimal

- $(\mathbf{757})_8 \rightarrow (?)_{16}$
- $(\mathbf{254})_8 \rightarrow (?)_{16}$

Exercises

- Convert following Decimal numbers to HexaDecimal/Octal
  - 255_{10}
  - 256_{10}
  - 257_{10}
- Convert following HexaDecimal numbers to Decimal, Octal
  - 99_{16}
  - 100_{16}
  - 101_{16}

Recursion : programming

- Create factorial
  - 5! = 5 x 4 x 3 x 2 x 1 = **120**
  - 2! = **2**
- Provide sum of Fibonacci numbers using recursion
  - fibonacci(13)
    - 0 + 1 + 1 + 2 + 3 + 5 + 8 + 13 = **33**
  - fibonacci(3)
    - 0 + 1 + 1 + 2 + 3 = **7**