January 8, 2026

Base 2, 8, 16

Binary $(\overset{7}{1}\overset{6}{1}\overset{5}{1}\overset{4}{1}\overset{3}{1}\overset{2}{1}\overset{1}{1}\overset{0}{1})_2 \rightarrow (\quad)_{10}$

$$1\cdot 2^7 + 1\cdot 2^6 + 1\cdot 2^5 + 1\cdot 2^4 + 1\cdot 2^3 + 1\cdot 2^2 + 1\cdot 2^1 + 1\cdot 2^0$$

$$= 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 =$$

$$= 255_{10}$$

$$(\overset{2}{3}\overset{1}{7}\overset{0}{7})_8 = 3\cdot 8^2 + 7\cdot 8^1 + 7\cdot 8^0 = 255_{10}$$

$$(\overset{1}{F}\overset{0}{F})_{16} \rightarrow (\quad)_{10}$$

base 16:

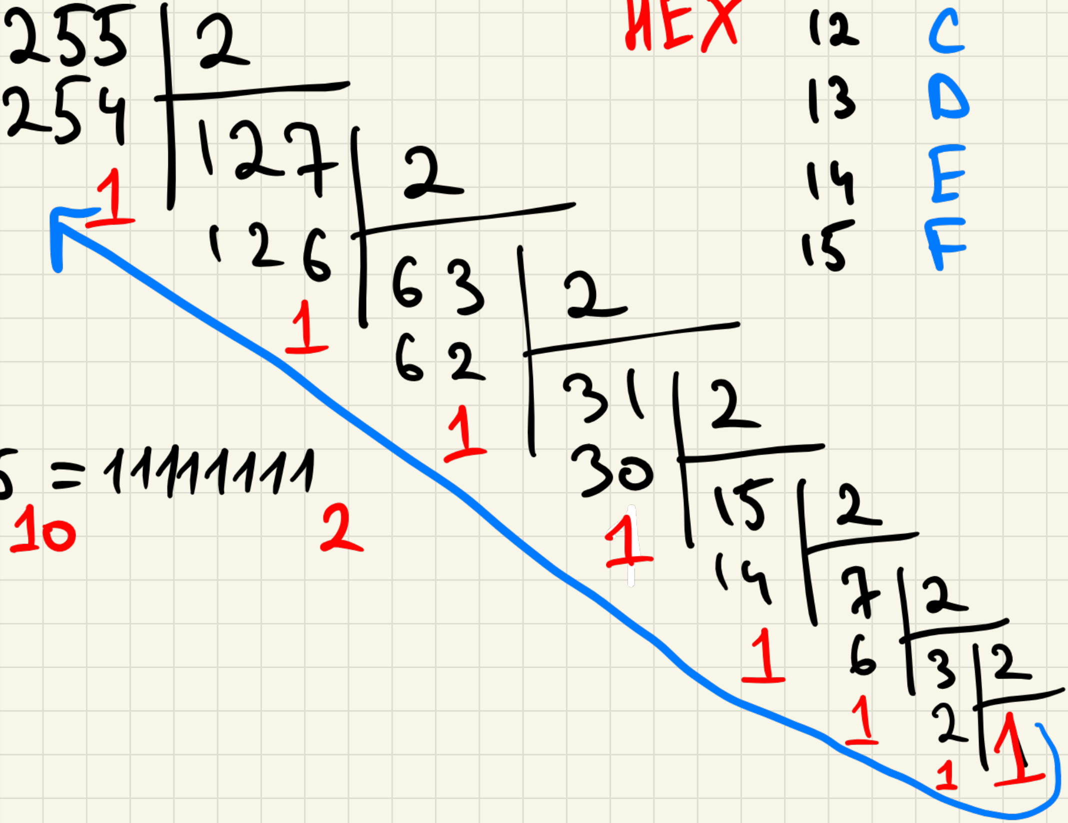
$16^{1} \cdot F + 16^{0} \cdot F = 16 \cdot 15 + 15 = 255_{10}$

Decimal

$$\begin{tikzcd}
 & (\quad)_2 \\
(\quad)_{10} \arrow[ur] \arrow[r] \arrow[dr] & (\quad)_8 \\
 & (\quad)_{16}
\end{tikzcd}$$

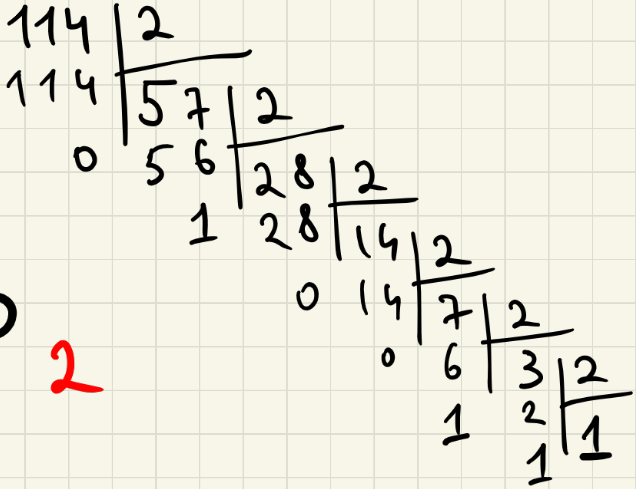
HEX

10	A
11	B
12	C
13	D
14	E
15	F



$255_{10} = 11111111_2$

114_{10}



1110010_2

$(0.12)_{10} \rightarrow (\quad)_2 = (.000111)_2$

$0.12 \times 2 = \underbrace{0}.24$	0
$0.24 \times 2 = \underbrace{0}.48$	0
$0.48 \times 2 = \underbrace{0}.96$	0
$0.96 \times 2 = 1\underbrace{.92}$	1
$0.92 \times 2 = 1\underbrace{.84}$	1
$0.84 \times 2 = 1.68$	1 ↓

just fraction

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

Binary addition

$$\begin{array}{r} +\ 01100 \\ \underline{10001} \\ \boxed{11101} \end{array}$$

$$\begin{array}{cccccc} 1 & & 1 & 1 & & \\ + & 1 & 0 & 1 & 1 & 0 \\ & 1 & 0 & 1 & 1 & 1 \\ \hline \underline{1} & [0 & 1 & 1 & 0 & 1] \end{array}$$

$$(1)_2 + (1)_2 = (10)_2$$

$$(10)_2 + (1)_2 = (11)_2$$

It is overflow, machine should know that It is overflow

Binary subtraction

$$\begin{array}{r} 0 \\ -\ 0 \\ \hline 0 \end{array} \qquad \begin{array}{r} 1 \\ -\ 1 \\ \hline 0 \end{array} \qquad \begin{array}{r} 1 \\ -\ 0 \\ \hline 1 \end{array} \qquad \begin{array}{r} 1\leftarrow \ \ \\ 0 \\ -\ 1 \\ \hline 1 \end{array}$$

$$\begin{array}{r} 10110 \\ -\ 10010 \\ \hline 00100 \end{array} \qquad \begin{array}{r} 10110 \\ -\ 10011 \\ \hline 00011 \end{array}$$

1's complement

$(10101111)_2$ logic operation

1's compliment is inverse of digits

(01010000) 1's comp.

$+ \quad 1$

(01010001) 2's compliment

$(0101)_2 = (5)_{10}$

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$(r-1)$'s r's compliments

radix = base

$r = 10 \quad L = 4 \quad N = 2468 \quad r^4 = 1000$

$r^4 - 1 = 9999$

Therefore
$$\begin{array}{r} 9999\\ -\,2468\\ \hline 7531 \end{array}$$

Decimal $(185)_{10}$

Binary $(10111001)_2$

Binary Coded Decimal BCD

$$(\underbrace{4}\underbrace{5}\underbrace{9})_{10} \rightarrow (\quad)_{BCD}$$

$$\underline{\qquad\qquad} \quad \underline{\qquad\qquad} \quad \underline{\qquad\qquad}$$

0100 0101 1001

BCD range (0-9)

$$4_{10} + 8_{10} = 12_{10}$$

$$0100_2 + 1000_2 = 1100_2 \rightarrow 12_{10}$$

$$0110_2 \rightarrow 6_{10}$$

$$(\underbrace{0001}\,\underbrace{0010})_{BCD}$$

Binary Coded Decimal

$$\begin{array}{rr} & 162 \\ + & 769 \\ \hline & 931 \end{array}$$

$$\begin{array}{ccc} 0001 & 0110 & 0010 \\ 0111 & 0110 & 1001 \\ \hline 1000 & \underbrace{1100}_{\text{doesn't exist in BCD}} & \underbrace{1011}_{\text{more than 9}} \end{array}$$

to solve add 6_{10}

$$\begin{array}{ccc} & 0110 & 0110 \\ \hline \underbrace{1001}_{9} & \underbrace{0011}_{3} & \underbrace{0001}_{1} \end{array}$$

encoding → public UTF-8

encryption → special key

BOOLEAN LOGIC

$A+B$ → A or B

$A.B$ → A and B

A', $\bar{A}$ → NOT A

inputs

A	B	A.B	A+B	A'	B'
0	0	0	0	1	1
0	1	0	1	1	0
1	0	0	1	0	1
1	1	1	1	0	0

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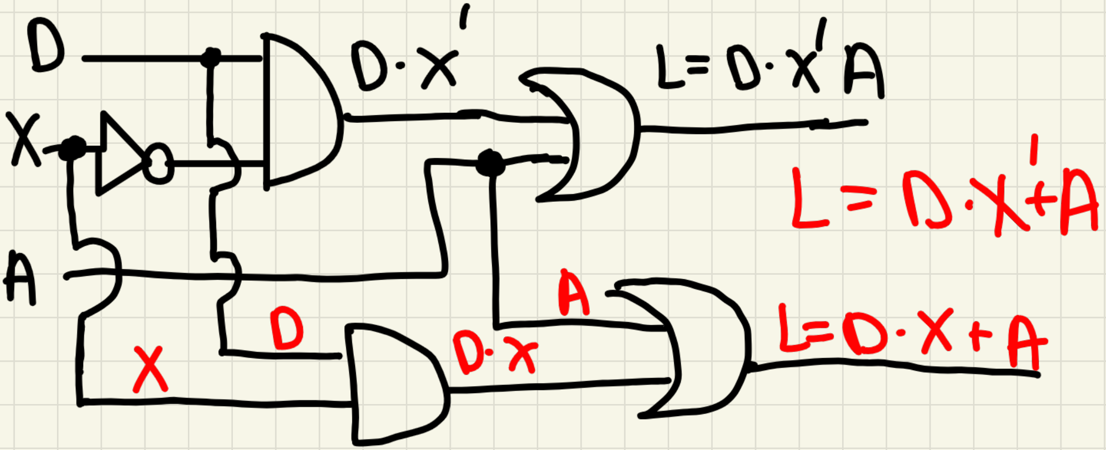
$$\underbrace{L}_{\text{output}} = \underbrace{\overset{\uparrow}{D} \cdot \overset{\uparrow}{X}' + \overset{\uparrow}{A}}_{\text{inputs}}$$

output

D	X	A	X'	D·X'	D·X'+A
0	0	0	1	0	0
0	0	1	1	0	1
0	1	0	0	0	0

0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	1	1	1
1	1	0	0	0	0
1	1	1	0	0	1



A	B	C	AB	A'C	BC		AB+A'C
0	0	0	0	0	0	0	0
0	0	1	0	1	0	1	1
0	1	0	0	0	0	0	0
0	1	1	1	0	1	1	1
1	0	0	0	0	0	0	0

1	0	1	0	0	0	0	0
1	1	0	1	0	0	1	1
1	1	1	1	0	1	1	1

$F(A,B,C) = (A+B)(A+C)$

$AA + AC + AB + BC$ Distributivity

$A + AC + AB + BC$ $A = AA$

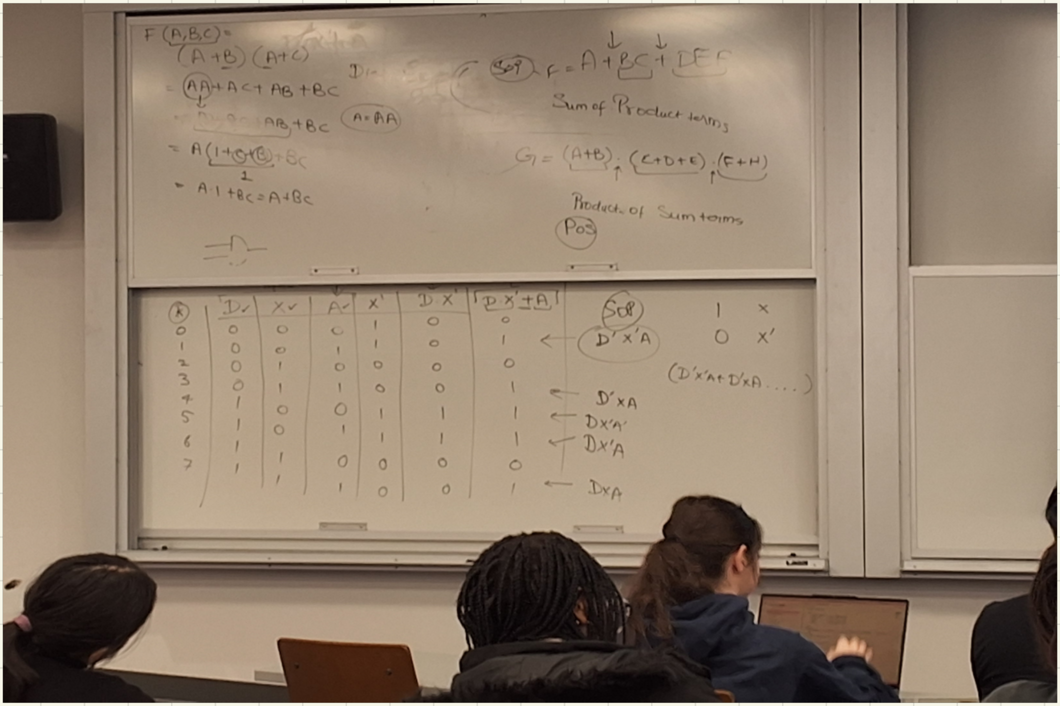
$A\underbrace{(1 + C + B)}_{1} + BC$

$A \cdot 1 + BC = \boxed{A + BC}$

Sum of Products SOP

$F(A,B,C) = A'B'C + ABC + A'BC'$

Product of Sum



$F(A,B,C) =$

$(A+B)(A+C)$

$= AA + AC + AB + BC$

$AB + BC$

$A = AA$

$= A(\underbrace{1+C+B}_{1}) + BC$

$= A \cdot 1 + BC = A + BC$

SoP $F = A + \underbrace{BC} + \underbrace{DEF}$

Sum of Product terms

$G = \underbrace{(A+B)} \cdot \underbrace{(C+D+E)} \cdot \underbrace{(F+H)}$

Product of Sum terms

PoS

k	D	X	A	X'	D·X'	D·X'+A	
0	0	0	0	1	0	0	
1	0	0	1	1	0	1	← D'X'A
2	0	1	0	0	0	0	
3	0	1	1	0	0	1	← D'XA
4	1	0	0	1	1	1	← DX'A'
5	1	0	1	1	1	1	← DX'A
6	1	1	0	0	0	0	
7	1	1	1	0	0	1	← DXA

SoP

1 X

0 X'

(D'X'A + D'XA . . . .)