

20-Feb-2024

Term 1/Week 4

- Decimal to Binary

Binary Arithmetic

HomeWork

- Binary to Decimal

$$(a) (10101)_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

$$= 16 + 0 + 4 + 0 + 1$$

$$= (21)_{10}$$

$$(b) (1110111)_2 = 1 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$$

$$= 64 + 32 + 16 + 0 + 4 + 2 + 1$$

$$= (119)_{10}$$

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Binary Addition

• Binary addition is simple and straight forward

For Ex:

$$\begin{array}{r} 61 \Rightarrow 11111 \\ + 23 \Rightarrow 10111 \\ \hline 84 \Rightarrow 1010100 = 84 \end{array}$$

• Binary subtraction

• It is possible to perform subtraction in the usual way, by borrowing from the next digit

	Quotient	Rem.
(a) 55	55/2	27 1
	27/2	13 1
	13/2	6 1
	6/2	3 0
	3/2	1 1
	1/2	0 1

$\therefore (55)_{10} = (110111)_2$

(b) 63

	Quo.	Rem		Quo.	Rem
63/2	31	1	3/2	1	1
31/2	15	1	1/2	0	1
15/2	7	1			MSB
7/2	3	1			

$\therefore (63)_{10} = (111111)_2$

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- However this creates problems when the answer is negative

Ex 1: $8 \Rightarrow 1000$

$$\begin{array}{r} 8 \\ - 3 \\ \hline 5 \end{array} \Rightarrow \begin{array}{r} 1000 \\ - 0011 \\ \hline 0101 \end{array}$$

can't borrow.

Ex 2: 3

$$\begin{array}{r} 3 \\ - 7 \\ \hline -4 \end{array} \Rightarrow \begin{array}{r} 011 \\ - 110 \\ \hline ?01 \end{array}$$

Traditionally, we check for the greater number and do the subtraction and then tag the negative sign!

• There is a smarter way of performing subtraction which is called "complement addition!"

• Let us first work with decimal numbers to understand the process

• Let us use 9's complement

For Ex: 9's complement of 2 is $9 - 2 = 7$

Similarly 9's complement of 5 is $9 - 5 = 4$

etc.

$$\begin{array}{r} \text{Ex. 1} \\ + 685 \\ - 273 \\ + 412 \end{array}$$

$$\begin{array}{r} 685 \\ 726 \leftarrow 9\text{'s complement} \\ \text{Add } \textcircled{1}411 \\ \hline \rightarrow 1 \leftarrow \text{Add "overflow"} \\ \hline 412 \checkmark \end{array}$$

Let us now try

$$\begin{array}{r} 273 \\ - 685 \\ \hline ? \end{array} \quad \begin{array}{l} \text{Traditional} \\ \text{way} \end{array} \quad \begin{array}{r} 685 \\ - 273 \\ \hline - 412 \end{array}$$

• Let us now try complement addition.

• A complement of a number is done digit by digit

• We can now replace a negative number by its 9's complement and ignore the negative sign.

For Ex: $-426 \xrightarrow{9\text{'s complement}} 573$

$$\begin{array}{ccc} & \swarrow & \searrow \\ (9-4) & (9-2) & (9-6) \\ 5 & 7 & 3 \end{array}$$

• Let us now perform subtraction as "complement addition"

$$\begin{array}{r} 273 \\ - 685 \xrightarrow{9\text{'s complement}} 314 \\ \hline 587 \text{ Add?} \end{array}$$

• There is no "carry"!
• If there is no 'carry', then it is a negative number! So, take the complement again to get the result!

$$587 \xrightarrow{9\text{'s complement}} -412$$

Home Work :

$$\begin{array}{r} 4285 \\ - 928 \\ \hline \end{array} \quad \begin{array}{r} 526 \\ - 4829 \\ \hline \end{array}$$

Use complement addition.