Decimal → Binary (Last class)

$0+0 \to 0$
$1+0 \to 1$
$0+1 \to 1$
$1+1 \to 10$

# Binary → Decimal

→ Let's say we have, 10110 → convert → Decimal

↳ 10110 = 10000 → $2^4$

+ 100 → $2^2$

+ 10 → $2^1$

It is the addition equivalent of these 3 number

10110

16
4
2

22

$(22)_{10} \longrightarrow \underbrace{(10110)}_{\text{Base 2}}{}_2$

Base 10 $\longrightarrow$ Base 2

Ex $1010 \longrightarrow 1000 \longrightarrow 2^3 \longrightarrow 8$

$+ 10 \longrightarrow 2^1 \longrightarrow 2$

$\boxed{1010}$ $\qquad$ $10$

4th 3rd 2nd 1st 0th

$10110 \rightarrow \underbrace{10000}_{2^4} + \underbrace{100}_{2^2} + \underbrace{10}_{2^1}$ (Binary addition)

Decimal Equivalent $\rightarrow 2^4 + 2^2 + 2^1$

$\rightarrow 22$

4 3 2 1 0

$10111 \rightarrow 10000 + 100 + 10 + 1$

$\rightarrow 2^4 + 2^2 + 2^1 + 2^0$

$\rightarrow 16 + 4 + 2 + 1$

$\rightarrow 23$ (odd)

$10110 \longrightarrow (1\times 2^4) + (0\times 2^3) + (1\times 2^2) + (1\times 2^1) + (0\times 2^0)$

Example

a) $(10010010)_2 \longrightarrow (146)_{10}$

$\hookrightarrow \underline{(1\times 2^7)} + \underline{(0\times 2^6)} + \underline{(0\times 2^5)} + \underline{(1\times 2^4)} + \underline{(0\times 2^3)} + \underline{(0\times 2^2)} +$

$\underline{(1\times 2^1)} + \underline{(0\times 2^0)}$

$\longrightarrow 128 + 16 + 2$

$\longrightarrow \underline{\underline{146}}$

Ex → $1011 \rightarrow 2^3 + 0 + 2^1 + 2^0 \rightarrow 11$

$100000 \rightarrow 32$

$111111 \rightarrow 63$

$1001011011$

9 8 7 6 5 4 3 2 1

↳ $\underbrace{2^9 + 2^6 + 2^4 + 2^3 + 2^1 + 2^0}$

↳ $603$

2

↳ $(156)_{10} \longrightarrow$ (Binary)

$(10011100)_2$

Binary

156 ⟶ 0

78 ⟵ 156/2 ⟶ 0 ↓

$78 \times 2 = 156$

Bin

$39 \times 2 = 78$

$19.5 \times 2 = 39$

$9.5 \times 2 = 19$

$4.5 \times 2 = 9$

$2 \times 2 = 4$

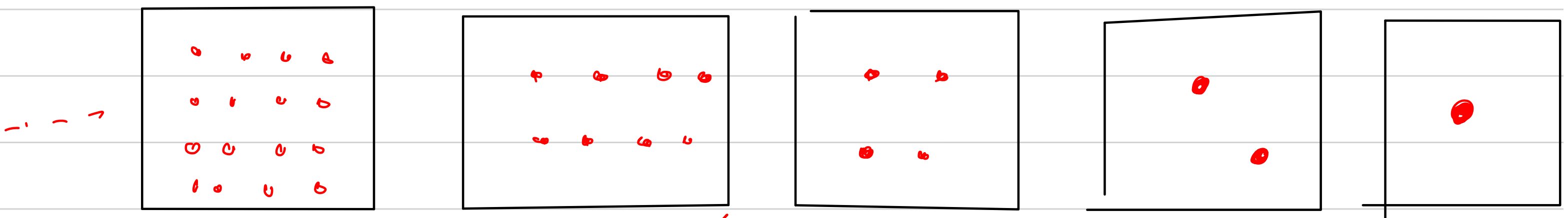
$1 \times 2 = 2$

$$(111111)_2 \rightarrow \underbrace{2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0}_{\text{easy}}$$

$$\rightarrow 32 + 16 + 8 + 4 + 2 + 1$$

$$\rightarrow \boxed{63}$$

We want to represent decimal as power of 2



$2^4$ $2^3$ $2^2$ $2^1$ $2^0$

What is the biggest power of 2 $<=$ ~~28~~ 13

$27 \rightarrow 2^4$

$11 \rightarrow 2^3$

$3 \rightarrow 2^1$

$1 \rightarrow 2^0$

$28 \rightarrow 2^4$

$12 \rightarrow 2^3$

$4 \rightarrow 2^2$

$13 \rightarrow 2^3$

$5 \rightarrow 2^2$

$1 \rightarrow 2^0$

$134 \longrightarrow 2^7 + 2^2 + 2^1$

$\longrightarrow 10000110$

$1349 - 2^{10} \to 325$

$1349 \longrightarrow 2^{10}$

$325 \longrightarrow 2^8$

$69 \longrightarrow 2^6$

$5 \longrightarrow 2^2$

$1 \longrightarrow 2^0$

$0$

$10101000101$

$4$

1349 $\longrightarrow$ 10101000101

674.5 × 2 = 1349

337

168

84

42

21

10.5

5

2

1

10

Q→ Example → Convert 89 to binary

| 64 | 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|---|
| $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| 1 | 0 | 1 | 1 | 0 | 0 | 1 |

$89 - 64 = 25$

$25 - 16 = 9$

$9 - 8 = 1$

$1 - 1 = 0$

→ 1011001

Qs Convert the following decimal values to binary

a) $37 \rightarrow 2^5 + 2^2 + 2^0 \rightarrow 100101$

b) $22 \rightarrow 2^4 + 2^2 + 2^1 \rightarrow 10110$

c) $45 \rightarrow 2^5 + 2^3 + 2^2 + 2^0 \rightarrow 101101$

d) $98 \rightarrow 2^6 + 2^5 + 2^1 \rightarrow 1100010$

e) $156 \rightarrow 2^7 + 2^4 + 2^3 + 2^2 \rightarrow 10011100$

approx

$2^{10} \approx 10^{3}$

$2^{20} \approx 10^{6}$

$2^{30} \approx 10^{9}$

# Binary Addition

$0_2 + 0_2 \longrightarrow 0_2$

$0_2 + 1_2 \longrightarrow 1_2$

$1_2 + 0_2 \longrightarrow 1_2$

$1_2 + 1_2 \longrightarrow (10)_2$

1star ✱ + ✱ 1star $\longrightarrow$ ✱ ✱ 2stars

1 star, 1 star, 10 star

$\underbrace{10}$ ✱ ✱ + $\underbrace{100}$ ✱ ✱ ✱ ✱

6 stars decimal

✱ ✱ ✱ ✱ ✱ ✱

$(110)_2$

$1+1 \rightarrow \underline{10}$

$$\begin{array}{r} 1\,0\,1\,1\,1\,0\,1\,1\,1 \\ +\;1\,1\,1\,0\,0\,1 \\ \hline 1\,1\,0\,1\,1\,0\,0\,0\,0 \end{array}$$

$(1_2 + 1_2) + 1_2$

$(10)_2 + 1$

$10$

$1$

$(11)_2 \longrightarrow (3)_{10}$

a) $1 + 11 \rightarrow 100$

$$\begin{array}{r} 11 \\ +\ 1 \\ \hline 100 \end{array}$$

$$\begin{array}{r} 1010 \\ 11 \\ \hline 1101 \end{array}$$

b) $1010 + 11 \rightarrow 1101$

$(11_2) \rightarrow 2^1 + 2^0$

$(3_{10})$

c) $100101 + 10101 \rightarrow 111010$

$$\begin{array}{r} 100101 \\ 10101 \\ \hline 111010 \end{array}$$

$$\begin{array}{r} 1 \\ +\ 1 \\ \hline 11 \end{array}$$

$(1_2 + 1_2) + 1_2$

$(10)_2 + 1_2 \rightarrow (11)_2$

$2_{10} \quad 1_{10} \rightarrow 3_{10}$

# PUZZLE → Aman throws a party & everyone (only students) from PEC is invited. Aman has 1000 bottles of (decimal) cold drinks & there is one bottle which is poisoned. Now Aman has to eliminate this bottle. For this he has got 10 rats. Aman can let rats drink the cold drink from bottle & if the rats fell asleep then they drank from the poisoned bottles.

Poison takes 1 hr to show the symptom, & almost 1 hr is left for party.

1 10 11 100 101 110

1000 bottles → i label binary

1101

3 2 1 0th

x 1010

| R9 | R8 | R7 | R6 | R5 | R4 | R3 | R2 | R1 | R0 |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 8 | 7 | 6th | 5th | 4th | 3rd | 2nd | 1st | 0th |

We labelled every bottle a binary symbol.
Now take each bottle one by one, and choose the ith rat to drink the bottle if ith bit is 1

5 4 3 2 1 0

100101

R5 R2 R0

HW 100000 → bottles

How many minKats you require for the expen

# Gates → special electronic circuits called as logic gates → Input pins, output pin

* NOT
* AND
* OR

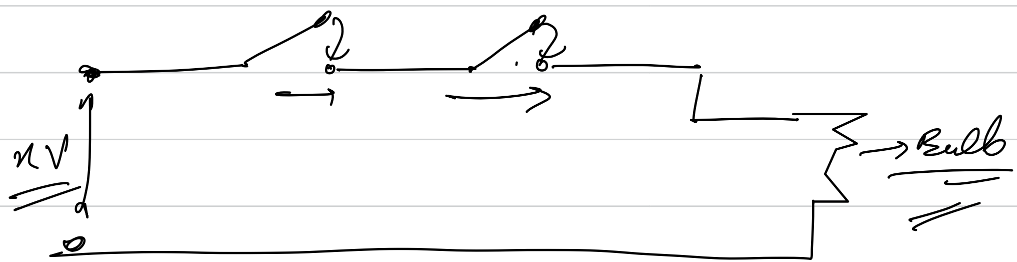
* NOT

Input → 1 pin
Output → 1 pin

| i/p | o/p |
|---|---|
| 1 | 0 |
| 0 | 1 |

* AND → 2 input 1 output

| A | B | o/p |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |



* OR → 2 i/p 1 o/p

| A | B | o/p |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

→ parallel

# XOR Gate

2 i/p 1 o/p

| A | B | o/p |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

→ xor → and

| A + | B → | Base | Carry |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |

↳ base

Sum or Base: A xor B

Sum carry: A and B