Todays Content

1. Number System Basics
2. Binary to Decimal & Vice Versa
3. Adding 2 Binary Numbers
4. -ve numbers
5. Datatype range
6. When we multiply 2 numbers

$$S = 2^0 + 2^1 + 2^2 + \cdots + 2^{N-2} + 2^{N-1} + 2^N = 2^{N+1} - 1$$

$$2S = 2^1 + 2^2 + 2^3 + \cdots + 2^{N-1} + 2^N + 2^{N+1}$$

$$S = 2^0 + 2^1 + 2^2 + \cdots + 2^{N-2} + 2^{N-1} + 2^N$$

$$S = 2^{N+1} - 2^0 \Rightarrow 2^{N+1} - 1$$

$$S = 2^0 + 2^1 + 2^2 : 2^3 - 1$$

$$S = 2^0 + 2^1 + 2^2 + 2^3 = 2^4 - 1$$

Decimal Number System → Each Digit: [0 1 ... 9]
↳ Each power: [10]

10^3 [10^2 10^1 10^0]

3 4 2 = $3*10^2 + 4*10^1 + 2*10^0 = 342$

2 5 6 3 = $2*10^3 + 5*10^2 + 6*10^1 + 3*10^0 = 2563$

Binary Number System → Each Digit: [0 1]
↳ Each power: [2]

[2^5 2^4 2^3 2^2 2^1 2^0]

1 0 0 1 0 1 = $2^5*1 + 2^2*1 + 2^0*1 = 37$

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

1 0 0 1 1 = $2^4*1 + 2^1*1 + 2^0*1 = 19$

1 1 0 0 1 = 25

2^6 2^5 2^4 2^3 2^2 2^1 2^0

1 0 1 1 0 1 0 = $2^6 + 2^4 + 2^3 + 2^1 = 64 + 16 + 8 + 2 = 90$

Decimal to Binary →

2	37
2	18 : 1
2	9 : 0
2	4 : 1
2	2 : 0
2	1 : 0
	0 : 1

2	45
2	22 : 1
2	11 : 0
2	5 : 1
2	2 : 1
2	1 : 0
	0 : 1

37 : [2^5 2^4 2^3 2^2 2^1 2^0]

1 0 0 1 0 1

$= 2^5 + 2^2 + 2^0 = 37$

45 : [2^5 2^4 2^3 2^2 2^1 2^0]

1 0 1 1 0 1

$= 2^5 + 2^3 + 2^2 + 2^0 = 45$

Add 2 Decimal numbers: $c = s/10$ $d = s\%10$ 10 → Decimal

13/10 14/10

	1	1	
9/10	7	8	9
0	1	4	5
$s =$	9%10	13%10	14%10
$d = 0$	9	3	4

Add 2 Binary Numbers $c = s/2$ $d = s\%2$ 2 → Binary Number System

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

1/2 3/2 2/2 1/2

$c =$	0	1	1	0		
1/2	1	0	1	1	0	→ 22
0	0	0	1	1	1	→ 7
$s =$	1%2	1%2	3%2	2%2	1%2	
$d = 0$	1	1	1	0	1	→ 29

3/2 2/2 2/2 3/2 2/2

$c =$	1	1	1	1	1
0	1	1	0	1	1
0	1	0	1	1	1
$s =$	3%2	2%2	2%2	3%2	2%2
$d =$	1	1	0	0	1	0

8 bit Numbers:

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

13 : 0 0 0 0 1 1 0 1

-13 : 1 0 0 0 1 1 0 1 * wrong way to represent -ve :

* 13 : 0 0 0 1 1 0 1

↑

4 : 0 0 0 0 0 1 0 0

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

-17 : 1 0 0 1 0 0 0 1 =

Q? Correct way to get negative:

$-a = 2'a = \sim a + 1$.

$1 \rightleftarrows 0$

a = 13 : 0 0 0 0 1 1 0 1

$\sim a$: 1 1 1 1 0 0 1 0

1 : 0 0 0 0 0 0 0 1

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

-13 -a : 1 1 1 1 0 0 1 1 $= 2^7 + 2^6 + 2^5 + 2^4 + 2^1 + 2^0 = 243$

↳ LSB : MSB ? > All bits combined.

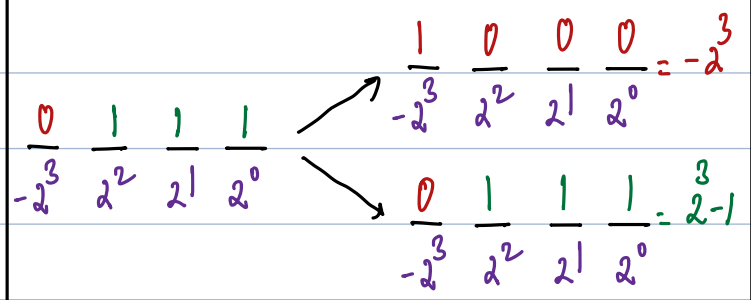
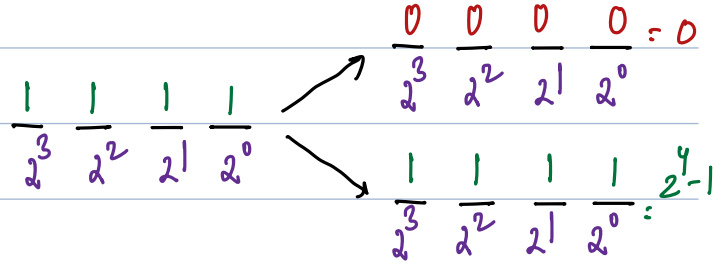
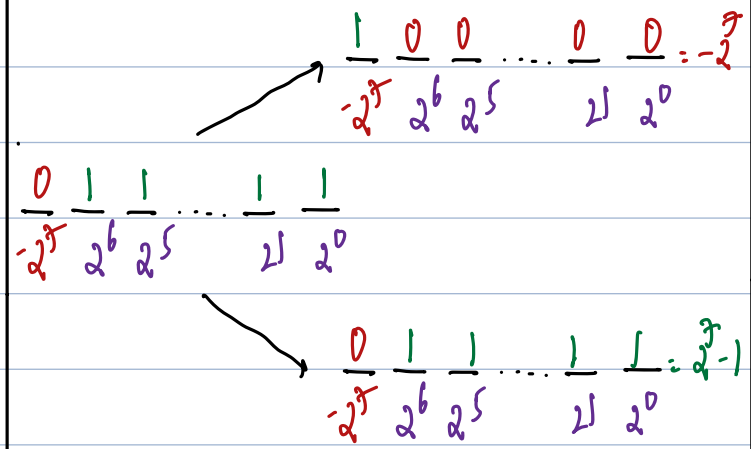
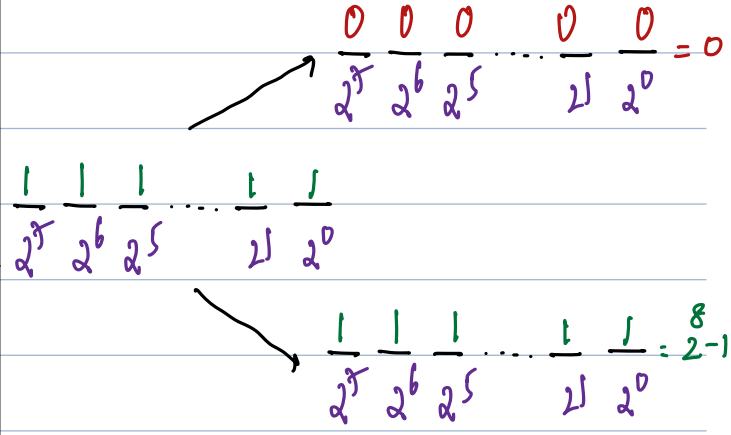
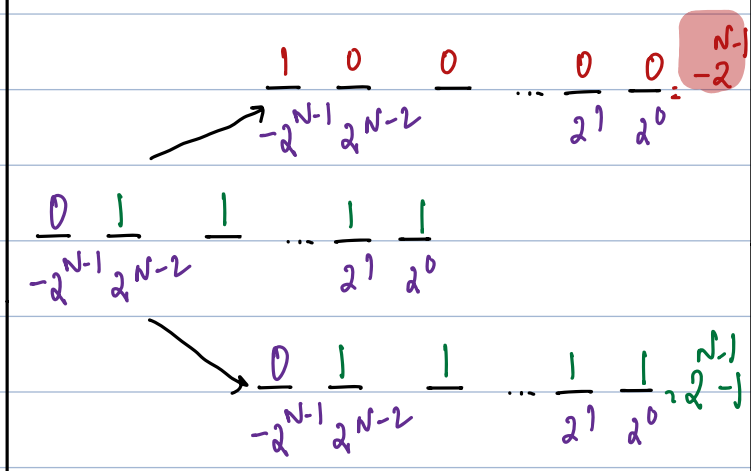
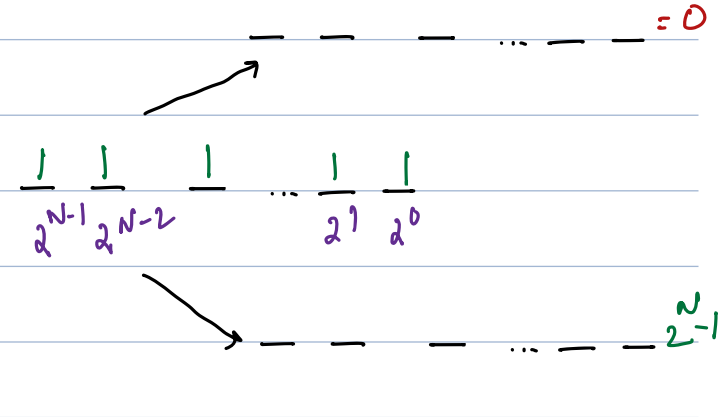
: MSB base valu : -ve

$-2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

-a : 1 1 1 1 0 0 1 1 $: -2^7 + 2^6 + 2^5 + 2^4 \ldots 2^1 + 2^0$

$: -128 + 115 = -13$

Q: Numbers — unsigned int a = 10;

#bits	Signed : MSB base value is -ve	Unsigned : MSB base value is +ve
4		
8		
N		

Datatype Ranges:

#datatype	#bits N	Signed: Min	Signed: Max	Unsigned: Min	Unsigned: Max
		-2^{N-1}	$2^{N-1}-1$	0	2^N-1
int	32	-2^{31} $\{-2*10^9$	$2^{31}-1$ $2*10^9\}$	0 $\{0$	$2^{32}-1$ $4*10^9\}$
long	64	-2^{63} $\{-8*10^{18}$	$2^{63}-1$ $8*10^{18}\}$	0 $\{0$	$2^{64}-1$ $16*10^{18}\}$

Approximations: $2^{10} = 1024 \approx 1000 = 10^3$ # $2^{10} \approx 10^3$

Case1:

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

Cube on both side

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

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

Multiply by 2

$2^{31} \approx 2*10^9$

Multiply by 2

$2^{32} \approx 4*10^9$

Case2:

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

power 6 on both side

$(2^{10})^6 \approx (10^3)^6$

$2^{60} \approx 10^{18}$

Multiply by 2^3

$2^{63} \approx 8*10^{18}$

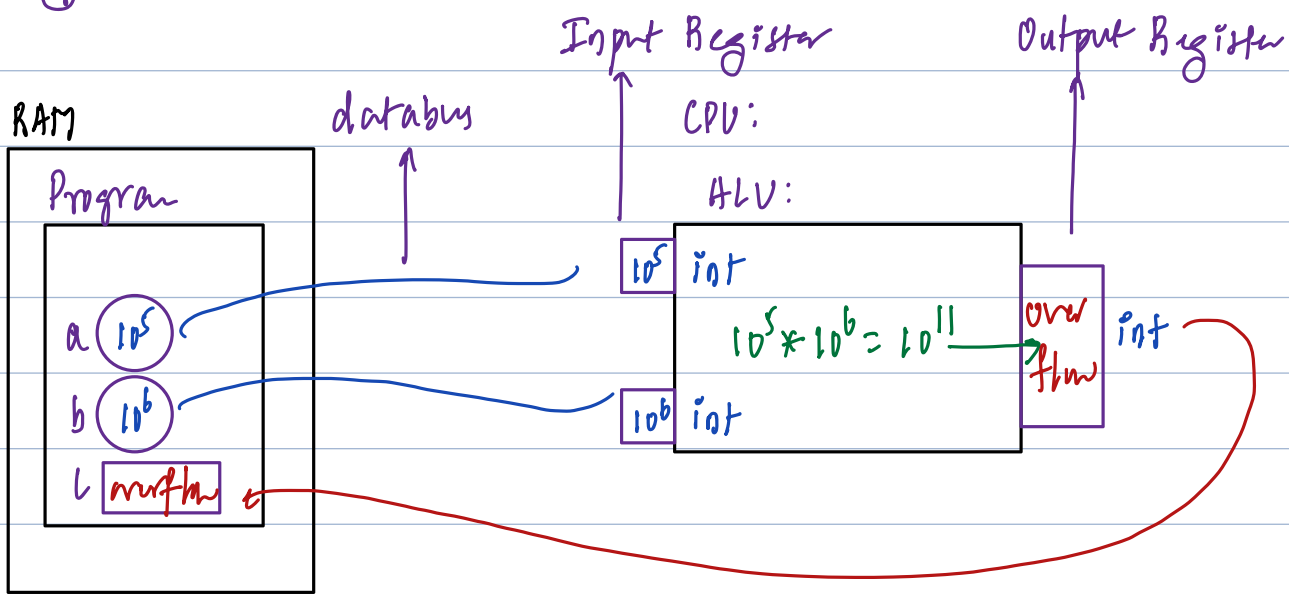
Q1: int a = 10^5, b = 10^6

int c = a * b; # $10^5 * 10^6 = 10^{11}$

print(c); #wrong

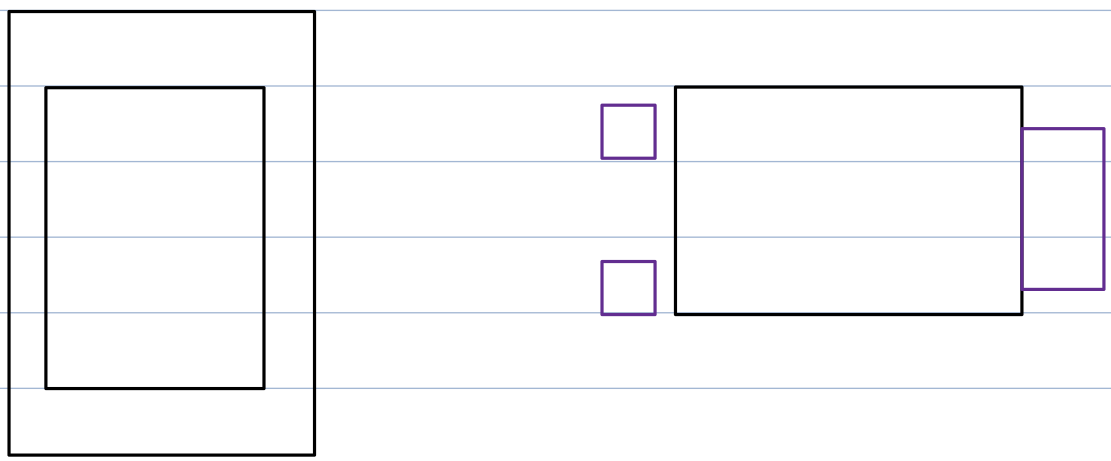
Q2: int a = 10^5, b = 10^6 ✓

long c = a * b; ✓



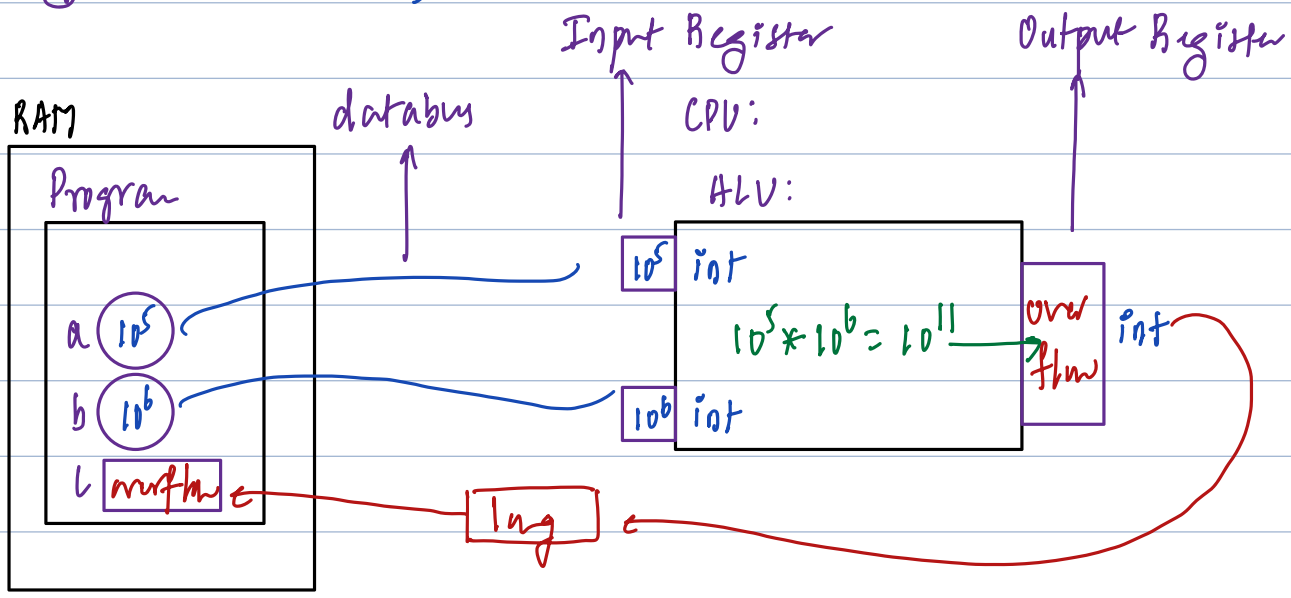
Q3: int a = 10^5, b = 10^6

long c = (long) a * b;



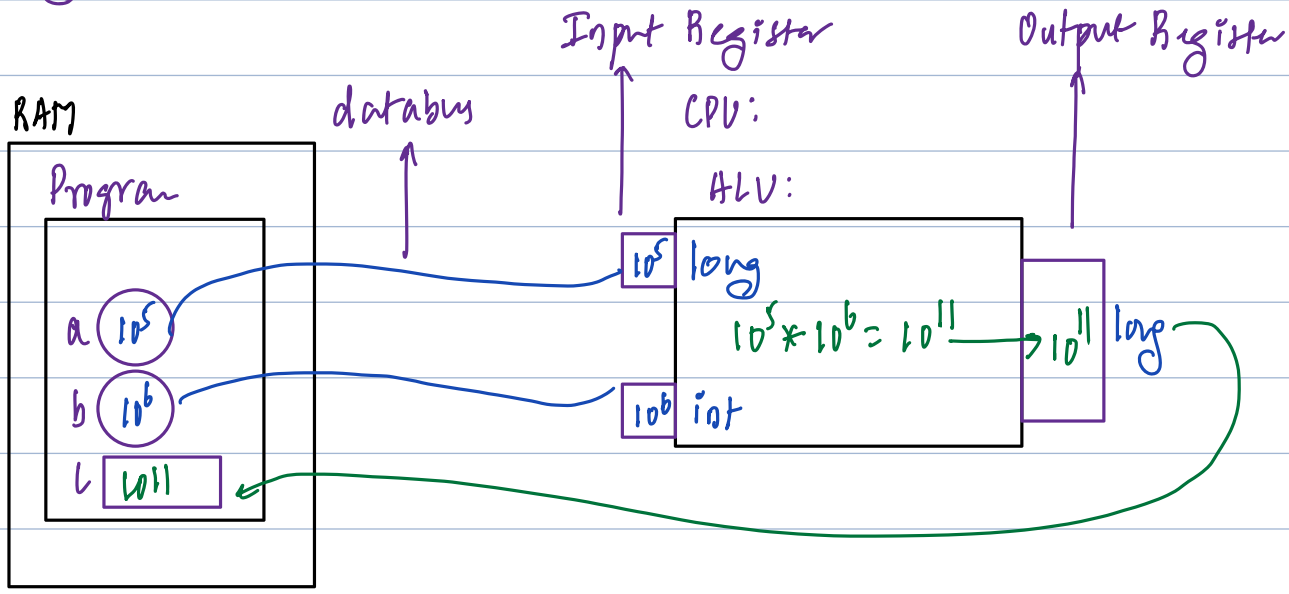
Q2: int a = 10^5, b = 10^6;

long c = (long)(a * b);



Q2: int a = 10^5, b = 10^6;

long c = (long)a * b;



long a = 10^5, b = 10^6;

long c = a * b;