Avg PSP 74 → 77 → 75 → 80

Monday cool

Decimal Number System 0—9 (base 10)

$$342 = 300 + 40 + 2$$
$$= 3*10^2 + 4*10^1 + 2*10^0$$

$$2563 = 2000 + 500 + 60 + 3$$
$$= 2*10^3 + 5*10^2 + 6*10^1 + 3*10^0$$

Binary Number System 0—1 (base 2)

- high voltage, on, true
- low voltage, off, false

$$110 = 1*2^2 + 1*2^1 + 0*2^0$$
$$= 4 + 2 + 0 = 6$$

$$1011 = 1*2^3 + 0*2^2 + 1*2^1 + 1*2^0$$
$$= 8 + 0 + 2 + 1 = 11$$

Binary to Decimal

$$10101 = 2^4 + 2^2 + 2^0 = 16 + 4 + 1 = 21$$

$$1011010 = 2^6 + 2^4 + 2^3 + 2^1 = 64 + 16 + 8 + 2 = 90$$

Decimal to Binary

int x = 5; → decimal

store in binary

remainder ↓

2	20	0
2	10	0
2	5	1
2	2	0
2	1	1
	0	

↑

4	3	2	1	0
1	0	1	0	0

$2^4 + 2^2 = 16 + 4 = 20$

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

↑

101101 (Ans)

Addition of Decimal Numbers

```
  1  1   → carry
  3  6  8
+ 4  5  3
-------
  8  2  1
```

Addition of Binary Numbers

```
  1  1  1   1
     1  0  1  0  1   → 21
+    1  1  0  1   → 13
-----------------
  1  0  0  0  1  0   → 34
```

$2^5 + 2^1$

1 + 1 = 2 → 10 (carry)

```
  1   1
  1 1 0 1 0 1  → 53
+ 1 0 0 1 1 0  → 38
-------------
1 0 1 1 0 1 1  → 91
```

```
  1 1
  1 0 1 1 0  → 22
+ 0 0 1 1 1  → 7
-------------
1 1 1 0 1    → 29
```

Bitwise operators

XOR → Addition without carry

A	B	AND A & B	OR A | B	XOR A ^ B
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	0

AND: All 1's ⇒ 1, else ⇒ 0

OR: All 0's ⇒ 0, else ⇒ 1

XOR: Same Same puppy shame 😊

A	~A (Not)
0	1
1	0

Q. 5 & 6

```
5 → 1 0 1
6 → 1 1 0   (&)
-----------
    1 0 0  → 4 (Ans)
```

2) 20 | 45

20 → 1 0 1 0 0

or

45 → 1 0 1 1 0 1

1 1 1 1 0 1

5 4 3 2 1 0

$2^5 + 2^4 + 2^3 + 2^2 + 2^0 = 32 + 16 + 8 + 4 + 1$

$= \underline{61}$ (Ans)

3) 20 ^ 45

20 → 1 0 1 0 0

^

45 → 1 0 1 1 0 1

1 1 1 0 0 1 → $32 + 16 + 8 + 1 = \underline{57}$ (Ans)

5 4 3 2 1 0

Binary Representation of Negative Numbers

45 → 1 0 1 1 0 1

int x = 45;

4 Bytes → 32 bits 00....0101101

8 bit system (our understanding)

7 6 5 4 3 2 1 0

45 → 0 0 1 0 1 1 0 1

flip bits → 1 1 0 1 0 0 1 0 → 1's compliment

Add 1 → + 0 0 0 0 0 0 0 1

-ve bit (1) 1 0 1 0 0 1 1 → 2's Compliment

$-2^7 + 2^6 + 2^4 + 2^1 + 2^0$

$= -128 + 64 + 16 + 2 + 1 = \underline{-45}$

Q → What is binary for -3 in 8 bit system.

	7	6	5	4	3	2	1	0
3 →	0	0	0	0	0	0	1	1

Flip bits → 1 1 1 1 1 1 0 0

Add 1 → + 1

	7	6	5	4	3	2	1	0
	1	1	1	1	1	1	0	1

$-2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^0$

$= -128 + 64 + 32 + 16 + 8 + 4 + 1 = \underline{-3}$

Q → What is binary for -10 in 8 bit system.

	7	6	5	4	3	2	1	0
10 →	0	0	0	0	1	0	1	0

Flip → 1 1 1 1 0 1 0 1 (1)

Add 1 → 1

1 1 1 1 0 1 1 0 → $\underline{-10}$

Range of Datatypes

8 bit system → (-ve) — — — — — — — —

	7	6	5	4	3	2	1	0
min →	1	0	0	0	0	0	0	0

$-2^7 = \underline{-128}$

	7	6	5	4	3	2	1	0
max →	0	1	1	1	1	1	1	1

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

$= 2^7 - 1 = \underline{127}$

Range → [-128 127]

integers → 32 bit system

min → 1 0 0 . . . 0 → $-2^{31} = -2147483648$

$-2*10^9$ (aprox.)

max → 0 1 1 . . . 1 → $2^{30}+2^{29}+\ldots 2^1+2^0$

$= 2^{31}-1 = 2147483647$

$2*10^9$ (aprox.)

Range → $[-2^{31}\quad (2^{31}-1)]$

$\approx [-2*10^9 \quad 2*10^9]$

long → 8 bytes → 64 bits

min → $-2^{63} \approx -9*10^{18}$

max → $2^{62}+2^{61}+2^{60}+\ldots+2^0 = 2^{63}-1 \approx 9*10^{18}$

Range → $[-2^{63}\quad (2^{63}-1)] \approx [-9*10^{18} \quad 9*10^{18}]$

Constraints

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

int c = a * b ;

$10^5 * 10^6 = 10^{11}$ Integer overflow

long c = a * b;

(2) (1) (int)

10^{11} Integer overflow

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

(a * b) → int (2), then long (3)

10^{11} Integer overflow

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

Steps: 1, 2, 3 → long * long = long ✓, 4

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

Step 2: long * int = long ✓, step 3

Q → Given an integer array, find sum of elements.

```
int long sum = 0
for i → 0 to (N-1) {
    sum += A[i]
} return sum
```

~~// Partially successful~~ ✓

Constraints

$1 <= N <= 10^5$

$1 <= A[i] <= 10^6$

max

$N = 10^5$ $\forall i, A[i] = 10^6$

$sum = 10^6 + 10^6 + \ldots + 10^6$

$= 10^6 * 10^5 = 10^{11}$

$10^{11} > 2*10^9$ → Integer overflow

---

15 % 10 = 5 (remainder)

$0 <= A \% M < M$

→ popular $(10^9 + 7)$