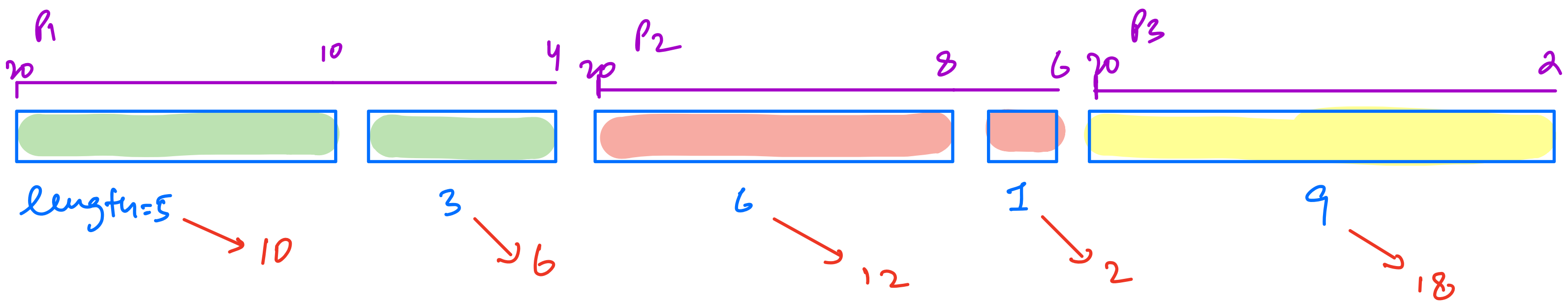
Searching 3 : Binary Search on Answer

Question 1 → Painter Partition Problem

Given N boards with length of each board.

1. All painters take T unit of time to paint 1 unit of length.
2. A board can only be painted by 1 painter.
3. A painter can only paint board placed next to each other.

Find min. no. of painters required to paint all boards in X unit of time. Return -1 if not possible.



$T = 2$

$X = 15$ → ans = -1

$X = 20 \rightarrow ans = 3$

$X = 40 \rightarrow ans = 2$

Code

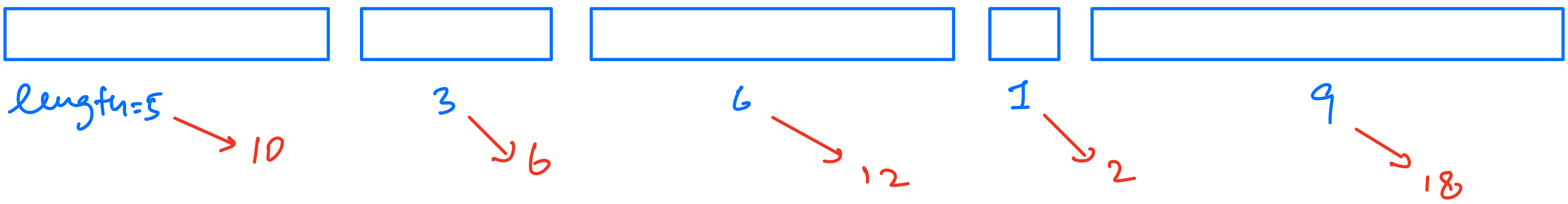
```
cnt=1 , p_time = X

for ( i=0 to n-1) {
    b_time = A[i] * T        → length of board i
    if ( b_time > X ) return -1
    if ( p_time >= b_time ) {
        p_time -= b_time
    }
    else {
        cnt ++
        p_time = X
        p_time -= b_time
    }
}
return cnt
```

TC = O(N)

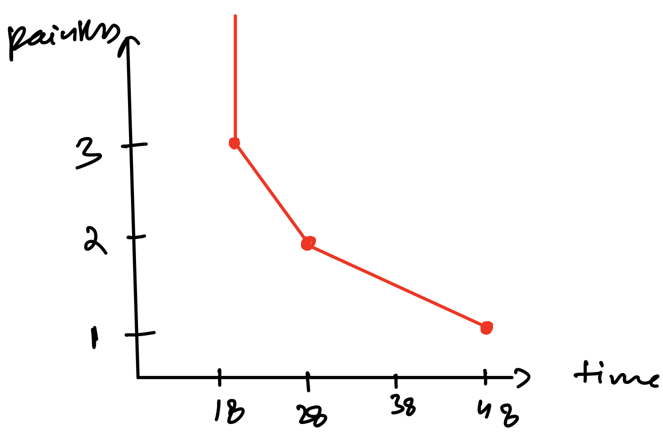
SC = O(1)

Part 2

find min. time to paint all boards if P painters are availble. (P > 0)



Painters		Time
1		10 + 6 + 12 + 2 + 18 = 48
2	$\boxed{\cancel{\frac{48}{2} = 24}}$	min{ max(10, 6+12+2+18) = 38
		max (10+6 , 12+2+18) = 32
		max(10+6+12 , 2+18) = 28
		max (10+6+12+2, 18) } = 30
>=3		18



$\boxed{time \propto \frac{1}{P}}$

binary search on answer

$A = [\underbrace{1 \quad 2 \quad 3 \quad 4}_{P_1} \quad \underbrace{100}_{P_2}]$ $\quad K = 2$

ans = 100

code

// Define search space

$l = \max_{\forall i}(A[i]) * T$, $r = (\sum_i A[i]) * T$

```
while ( l <= r) {

    // check if mid is answer

    mid = l + (r-l)/2        // mid -> time

    cut = minPainters( mid, A)   ----> TC = O(N)
    cut1 = minPainters (mid-1 , A)
    if ( cut == P && cut1 > P) {
        return mid
    }

    // decide whether to go left or right

    if ( cut <= P) {
        r = mid-1
```

}

else {

l = mid+1

}

}

$TC(N \times \log(\underbrace{sum(boards) - max(boards)}_{\text{range of search space}}))$

A = [5 3 6 1 9] T = 2 , P = 2

l	r	mid	cut , cut1
18	48	33	2 , 2
18	32	25	3
26	32	29	2 , 2
26	28	27	3
28	28	28	2 , 3

Question 2 → Aggressive Cows

A farmer has N stalls.

A[i] → location of ith stall in ascending order

cows are aggressive towards each other. So, the farmer wants to maintain min D distance b/w any pair of cows.

find max # of cows the farmer can have?

Note: In 1 stall, 1 cow can be present.

$$A = [\overset{0}{1} \quad \overset{1}{3} \quad \overset{2}{4} \quad \overset{3}{8} \quad \overset{4}{10} \quad \overset{5}{12} \quad \overset{6}{17}]$$

D = 10 ans = 2

D = 7 ans = 3

code

```
cnt = 1 , L = A[0]
for (i = 1 to n-1) {
|    if ( A[i] - L >= D ) {
```

```
        cnt++
        L = A[i]
    }
}
return cnt
```

TC = O(N)
SC = O(1)

Part 2

Cows are aggressive towards each other, farmer wants to maximize the minimum distance b/w any pair of cows.

Find max possible min. distance.

No. of cows = C (>= 2)

	0	1	2	3	4	5	6
A =	[1	3	4	8	10	12	17]

$$A = [\underbrace{1\ \ 3\ \ 4\ \ 8}_{7}\ \ \underbrace{10\ \ 12}_{4}\ \ \underbrace{17}_{5}]$$

C = 4

4 > 3

ans = 4

$$A = [\underbrace{1\ \ 3\ \ 4}_{3}\ \ \underbrace{8\ \ 10}_{6}\ \ \underbrace{12\ \ 17}_{7}]$$

$A = [0 \quad 3 \quad 4 \quad 7 \quad 9 \quad 10]$ $\qquad K=4$

$\underbrace{0 \quad 3 \quad 4}_{4} \quad \underbrace{4 \quad 7}_{3} \quad \underbrace{7 \quad 9 \quad 10}_{3}$

ans = 3

\# cows $\qquad$ max dis b/w each pair

$\boxed{C \propto 1/D}$ → binary search on answer.

Code

// Define search space

l = 1 (min dis b/w cows) , r = A[n-1] - A[0]

```
while ( l <= r ) {
    //check if mid is answer
    mid = l + (r-l)/2        // mid = distance
    cnt = maxCows(mid, A)  → O(N)
    cnt1 = maxCows (mid+1, A)
    if ( cnt == C  &&  cnt1 < C ) {
        return mid
    }
```

```
// decide whether to go left or right

    if ( cnt >= c) {
        l = mid+1
    }
    else {
        r = mid-1
    }
}
```

$TC = O(N * \log(r-l))$

$= O(N * \log(A[n-1] - A[0]))$

$SC = O(1)$