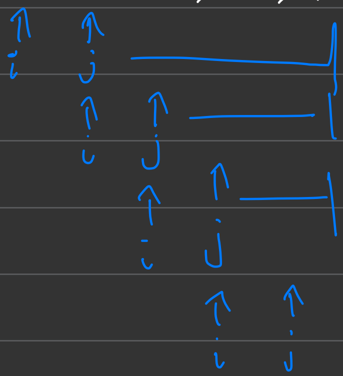
Brute force

An element a[i] can form pair with further elements if ($a[i] > a[j]$)

[5, 4, 3, 2, 1]



(5,4), (5,3), (5,2) (5,1)

(4,3), (4,2), (4,1)

(3,2), (3,1)

(2,1)

inversion_ct = 10

T.C → $O(n^2)$, SC → $O(1)$

Optimised approach (using Merge sort)

- In merge sort, while merging two halves, one thing is sure that both the halves are sorted

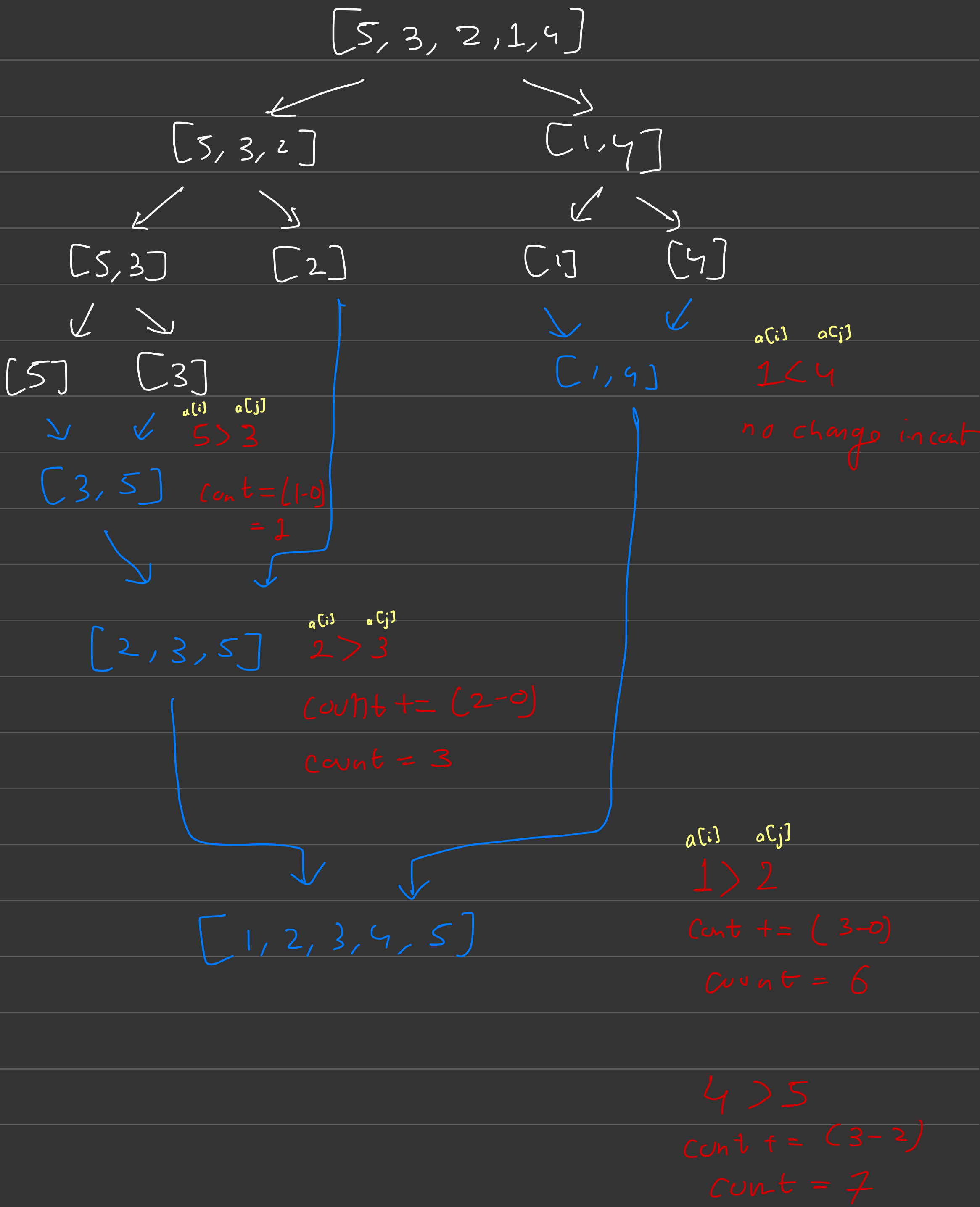
eg: $[\underset{\overset{\uparrow}{i}}{2}, \underbrace{3, 5}_{(mid-i)}] + [\overset{mid}{\underset{\overset{\uparrow}{j}}{1}}, 4]$

(if a[i] > a[j], a[j] forms inversion pairs with all the elements on the right of i to end of first arr i.e. mid.)

$\therefore$ count_inv += (mid − i)

In the above example, when being copied to temp array inv pairs → (1, 2), (1, 3), (1,5)
(4, 5)

T.C → O(nlogn)   S.C → O(n)


[5, 3, 2, 1, 4]
[5, 3, 2]
[1, 4]
[5, 3]
[2]
[1]
[4]
[5]
[3]
a[i] a[j]
5>3
[3, 5]
cont=(1-0)
=1
[1, 4]
a[i] a[j]
1<4
no change incnt
[2, 3, 5]
a[i] a[j]
2>3
count+=(2-0)
count = 3
[1, 2, 3, 4, 5]
a[i] a[j]
1>2
Cnt += (3-0)
count = 6
4>5
cnt += (3-2)
cunt = 7

```
int mergeSort (int arr[], int temp[], int l, int r)
      int mid, inv_count = 0;

      while (l < r) {
       mid = (l+r)/2;
       inv_count += mergeSort(arr, temp, l, mid);
       inv_count += mergeSort(arr, temp, mid+1, r);
       inv_count += merge(arr, temp, l, mid+1, r);
    }
   return inv_count;
}
```

```
int merge (int arr[], int temp[],
              int left, int mid, int right)
{ int i, j, k;
   int inv_count = 0;
   i = left ; j = mid ; k = left;
   // arr 1 -> l to mid-1        // arr 2 -> mid to r
  while ((i <= mid-1) && (j <= right)) {
     if (arr[i] <= arr[j]) { //No swapping
        temp[k++] = arr[i++]; //Copy to temp & i++
     } else { // Swapping & inv_count condn
        temp[k++] = arr[j++]; //copy to temp & j++
        inv_count += (mid - i); // inv_count condn
     }
  }
// If elems in arr[l] to arr[mid-1] are left, copy them
while (i <= mid-1)     temp[k++] = arr[i++]
// If elems in arr[mid] to arr[r] are left, copy them
while (j <= right)     temp[k++] = arr[j++]
for (i=left, i <= right; i++)   arr[i] = temp[i]
 return inv_count;
}
```

↑ copy temp arr elems to arr.