Radix Sort

(Least Sig → MSD)

num / exp ⇒ rem

rem % 10 ⇒ digit

	I	II	III	IV
1005	0010	1005	1005	0007
0236	1670	0007	0007	0009
0091	4580	0009	0009	0010
0386	0091	0010	0010	0091
0010	1111	1111	0091	0224
0007	0224	0224	1111	0236
0009	1005	0236	0224	0386
0224	0236	1670	0236	1005
1111	0386	4580	0386	1111
1670	0007	0386	4580	1670
4580	0009	0091	1670	4580
$exp = 10^0 = 1$	$exp \Rightarrow 10^1$	$exp \Rightarrow 10^2$	$exp = 10^3$	

val   (val/exp)%10   Count=4   exp=10

0

val	(val/exp)%10
1005	5
0236	6
0091	1
0386	6
0010	0
0007	7
0009	9
0224	4
1111	1
1670	0
4580	0

11

```
int res[] = new int[arr.length];

for(int idx = arr.length-1 ; idx >= 0 ; idx--){
    int val = arr[idx];
    int pos = (val / exp) % 10;
    int place = freq[pos];
    res[place-1] = val;
    freq[pos]--;
}
```

~~0091~~ ~~0026~~ 1005

7 6 5

11/8 7

0	1	2	3	4	5	6	7	8	9
0	~~4~~3	5	5	5	~~7~~6	8	9	10	10

→ pfa

0	1	2	3	4	5	6	7	8	9	10
0010	1670	4580	0091	1111	0224	1005	0026	0386	0007	0009

ans

DD - MM - YYYY

3 itr

LSD → MSD

1 1/2 0

n(freq) → 31

Day

12 04 1996
20 10 1996
05 06 1997
12 04 1989
11 08 1987

$num / 10^6$

n(freq) → 12

Month

05 06 1997
11 08 1987
12 04 1996
12 04 1989
20 10 1996

$(num / 10^4) \% 100$

n(freq) → 10000

Year

12 04 1996
12 04 1989
05 06 1997
11 08 1987
20 10 1996

$num \% 10^4$

11 08 1987
12 04 1989
12 04 1996
20 10 1996
05 06 1997

H.W.

Radix

Count

i = 1x1 → 1

i< n

```
for ( int i=1; i<n ; i = ixi){

        System.out.print(______);

}
```

O(1)

O(n)

O($\sqrt{n}$)

O(logn)

O(nlogn)

TLE

i

oper

i => n

infinite → T.L.E.

for (i = 1 ; i < n ; i = i × 2) {

} → O(1)

}

O(n)
O(1)
O(√n)
O(n/2)
O(log n)

TLE

Compilation error

K+1

i = 1   2   4   8 . . . . . . $2^k <= n$

O ⇒ 1   1   1   1 1

T.O. ⇒ (1 + 1 + 1 . . . . + 1) ⇒ K+1

K+1 =

$(K+1 <= \log_2 n + 1)$

$T.O. = K+1 <= \log_2 n + 1$

$2^K <= n$

$K <= \log_2 n$

$T.O. <= \log_2 n + 1$

$T.C. ⇒ O(\log_2 n)$

for (i = 1 ; i < n ; i = i × 5) {

——————— } O(1)

}

$$\boxed{k <= \log_5 n}$$

$$\overbrace{\qquad\qquad\qquad}^{k+1}$$

i = 5^0 5^1 5^2 5^3 . . . . . . $\boxed{5^k < n}$

oper → 1 1 1 1 1

T.C. → $\underbrace{1 + 1 + 1 + 1 + + + \ldots}_{k+1}$ → $k+1 <= (\log_5 n + 1)$

$$\boxed{T.C. \Rightarrow <= (\log_5 n) + 1}$$

$$\boxed{T.C. \rightarrow O(\log_5 n)}$$

for (i = 0 ; i < n ; i = i × 9) {

] − 1

}

TLE

$\log_9 n$

×

0 < n

i

0

0

0

0

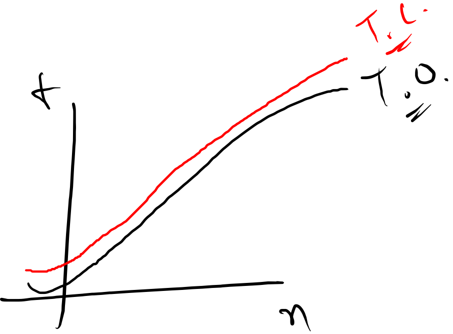
0

x

∞

~~infinite~~

TLE



$$\text{for} (i=0 ; \; i \le n ; \; i = i+2) \{$$

$$\} \to O(1)$$

$$\}$$

$$(T.C. \ge C.(T.O.))$$

$$T.O. \Rightarrow \overbrace{1+1+\dots+1}$$

$$\Rightarrow K+1 \quad -(1)$$

$$\overbrace{i=0 \quad 2 \quad 4 \quad 6 \quad 8 \quad 10 \quad \dots \quad 2K}^{K+1} \le n$$

$$1 \quad 1 \quad 1 \quad 1 \quad 1 \quad 1$$

✓ $T.O. \Rightarrow \frac{n}{2} + 1$

✓ $\boxed{T.C. \to O(n)}$

$C.(n)$

$O(\frac{n}{2})$

$\{C.n\}$

$$a_n \Rightarrow a + (n-1)d \Rightarrow$$

$$a_{K+1} \Rightarrow a + (K+1-1)d \Rightarrow 0 + K(2)$$

$$\Rightarrow 2K$$

$$2K \le n$$

$$\left(K \le \frac{n}{2}\right) \; -(II)$$

```
for ( i = 1 ; i * i <= n ; i++ ) {
    → O(1)
}
```

$i = 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad \ldots \quad k$

$i * i = 1 \quad 4 \quad 9 \quad 16 \quad 25 \quad \ldots \quad \boxed{k^2 <= n}$

$1 \quad 1 \quad 1 \quad 1 \quad 1$

T.O. $\Rightarrow \underbrace{1 + 1 \ldots + 1}_{k \text{ times}} \Rightarrow k <= \sqrt{n}$

$k^2 <= n$

$\boxed{k <= \sqrt{n}}$

$\boxed{\text{T.O.} <= \sqrt{n}}$, $\boxed{\text{T.C.} \Rightarrow O(\sqrt{n})}$

n times

```
for ( i=1 ; i<=n ; i++) {
    for(j=1 ; j<=100 ; j++) {        100 times
    }
    for (k=1 ; k<=n ; k=k*3){        log_3 n
    }
}
```

1 itr → $(100 + \log_3 n)$

$\boxed{n \text{ itr} \to n[100 + \log_3 n]}$

T.C. → $n[100 + \log_3 n] \Rightarrow 100n + (n\log_3 n)$

$\boxed{T.C. \to O(n\log_3 n)}$

$1 \rightarrow 10$

$\Downarrow$

10

$1 \rightarrow n$

$\Downarrow$

n

```
for ( i = 1 ; i <= n ; i++) {
    for ( j = i ; j <= n ; j++) {
        ———— } =
    }
}
```

i	j	opr
1	1, 2, 3, ... n ($\downarrow$ 1 1 1 1)	n
2	2, 3, 4, ... n	$n-1$
3	3, 5, 6, ... n	$n-2$
⋮		
n	n	1

$T.C. \Rightarrow n + (n-1) + (n-2) + \dots + 1$

$\Rightarrow \frac{n(n+1)}{2}$, $T.C. \Rightarrow O(n^2)$

(inp: n, m, p)

for (i=1 ; i<=n ; i++) {

for (j=1 ; j<=m ; j++) {

for (k=1 ; k<=p ; k++) {

}

}

}

T.C. => m.n.p

~~T.C~~

T.C. => O(m.n.p)

$n+1$ for (i = 0 ; i <= n ; i++) {

}

T.O. ⇒ n + m + 2

$\boxed{\text{T.C.} \Rightarrow O(n+m)}$

$m+1$ for (j = 0 ; j <= m ; j++) {

}

n

$n \log n$

$\log n$

$\sqrt{n}$

$n/2$

T.C.E

$n.m.p$

$n+m$

n^2

```
for (          ) {
    for (          ) {
    }
}
```

k times

```
for ( i = 1 ; i <= k ; i++) {
    for( j = 0 ; j <= n ; j = j + k) {
        ———————— } => O(1)
    }
}
```

$\left(\frac{n}{k}+1\right)$

T +1 times

T.O. => $k \cdot \left(\frac{n}{k}+1\right)$

$\boxed{T.O. \Rightarrow (n + k)}$

O(n)

(k => constant)

O(n)

$1 \rightarrow \left(\frac{n}{k}+1\right)$ times

$k \Rightarrow k\left[\frac{n}{k}+1\right]$ times

$\boxed{T.O. \Rightarrow [n+k] \text{ times}}$

T.C. => O(n)

k

i = 1 2 3 4 5 6 . . . . . . k

j = 0 . . . .

k

2k

3k

:

:

$\boxed{T.k <= n}$

$\left(\frac{n}{k}+1\right)$

$\left[T \Rightarrow \frac{n}{k}\right]$

```
for(i=1, j=1 ; i<=n && j<=n; i++) {
    ________________ } -> O(1)

    if(i==n && j<=n){
        j++;
        i=1;
    }
}
```

T.O. => n^2

T.C. => $O(n^2)$

oper

j=1   i=1, 2, 3, ... n -> n

j=2   i=1, 2, 3, ... n -> n

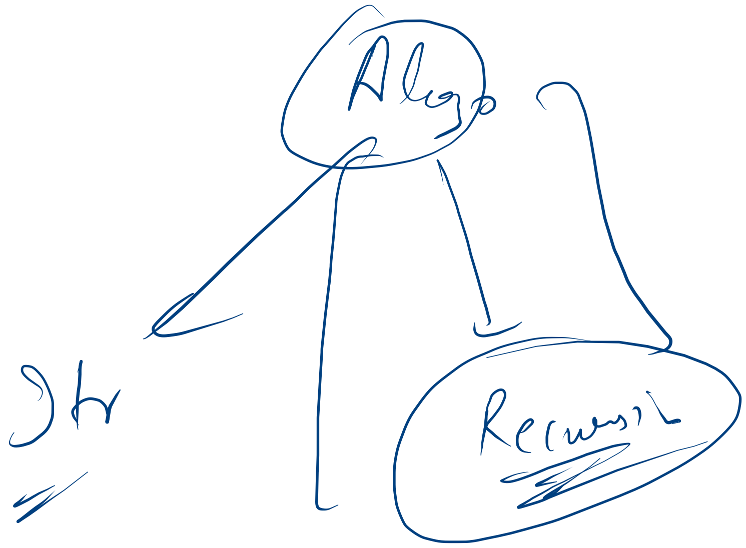
j=3   i=1, 2, 3 .... n -> n

j=4   i=1, 2, 3 .... n -> n

j=n   i=1 .... n -> n

j=n+1

n x n


Algo
Itr
Recursion

$$S \Leftarrow n^n \Rightarrow \overbrace{n \cdot n \cdot n \cdot n \cdot \cdots}^{n}$$

```
for ( i => 1 ; i <= n ; i++ ) {
    for ( j => 1 ; j <= n ; j++ ){
        for ( k => n ; j <= n ; k++ ){
            .
            .
            .
```