5	6	3	-1	2	4	3	5	-3	7
0	1	2	3	4	5	6	7	8	9

classmate
Date
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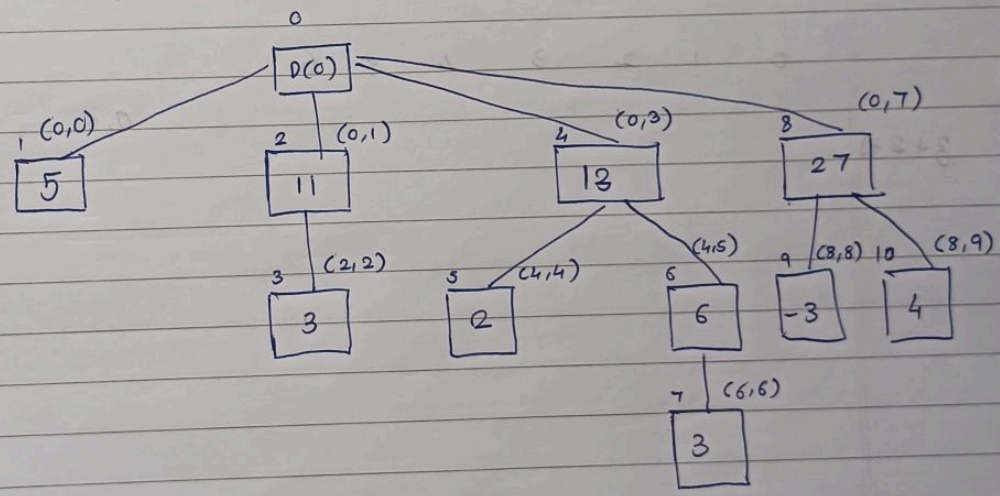
Fenwick Tree

* To find Parent Node (flip Rightmost 1)

		Parent
1 - 0001	- 0000	- 0
2 - 0010	- 0000	- 0
3 - 0011	- 0010	- 2
4 - 0100	- 0000	- 0
5 - 0101	- 0100	- 4
6 - 0110	- 0100	- 4
7 - 0111	- 0110	- 6
8 - 1000	- 0000	- 0
9 - 1001	- 1000	- 8
10 - 1010	- 1000	- 8



Theory

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no. of elements to be considered from start index

Tree Index

1 — $0 + 2^0$ → (0, 0)

↑ Start index in array

2 — $0 + 2^1$ — (0, 1)
3 — $2^1 + 2^0$ — (2, 2)
4 — $0 + 2^2$ — (0, 3)
5 — $2^2 + 2^0$ — (4, 4)
6 — $2^2 + 2^1$ — (4, 5)
7 — $[2^2 + 2^1] + 2^0$ — (6, 6)
8 — $0 + 2^3$ — (0, 7)
9 — $2^3 + 2^0$ — (8, 8)
10 — $2^3 + 2^1$ — (8, 9)

* Prefix Sum

(0, 3) = 3+1 = 4 → starting tree node no. (Index (4) —Parent→ Node (0)) (from tree)

(0, 3) = 13

(0, 8) = index (9) —Parent→ Node (8) —Parent→ Node (0)
= -3 + 27
= 24

(0, 5) = ~~2+13~~ index (6) → Node (4) → Node (0)
= ~~15~~ 6 + 13
= 19

(0, 6) = index (7) → node (6) → Node (4) → Node (0)
= 3 + 6 + 13
= 22

Algo

5	6	3	-1	2	4	3	5	-3	7
0	1	2	3	4	5	6	7	8	9

1) To get Parent
Take Two's complement
AND with OG
Subtract from OG

Tree index - 1 - 000001 → 1st Comp

```
  111110
+      1
--------
  111111
AND
  000001
--------
  000001
-
  000001
--------
  000000  - 0
```

9 - 001001 →

```
  110110
+      1
--------
  110111
AND
  001001
--------
  000001
```

```
  001001
- 000001
--------
  001000  - 8
```

3 - 000011 →

```
  111100
+      1
--------
  111101
AND
  000011
--------
  000001
```

```
  000011
- 000001
--------
  000010  - 2
```

Initially in all tree nodes (boxes) 0 is stored

2) Get Next

Take two's comp

AND with OG

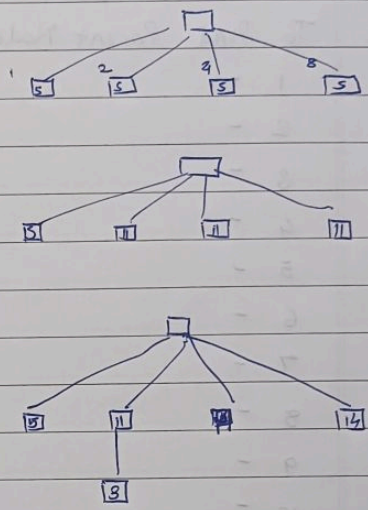
ADD to OG

if index 0 → value gets added

if not 0 → Not added

Next (1) —

```
  0001
  1000   2's
  ----
  1111
  0001   AND
  ----
  0001
  0001   +
  ----
  0010 — 2
```

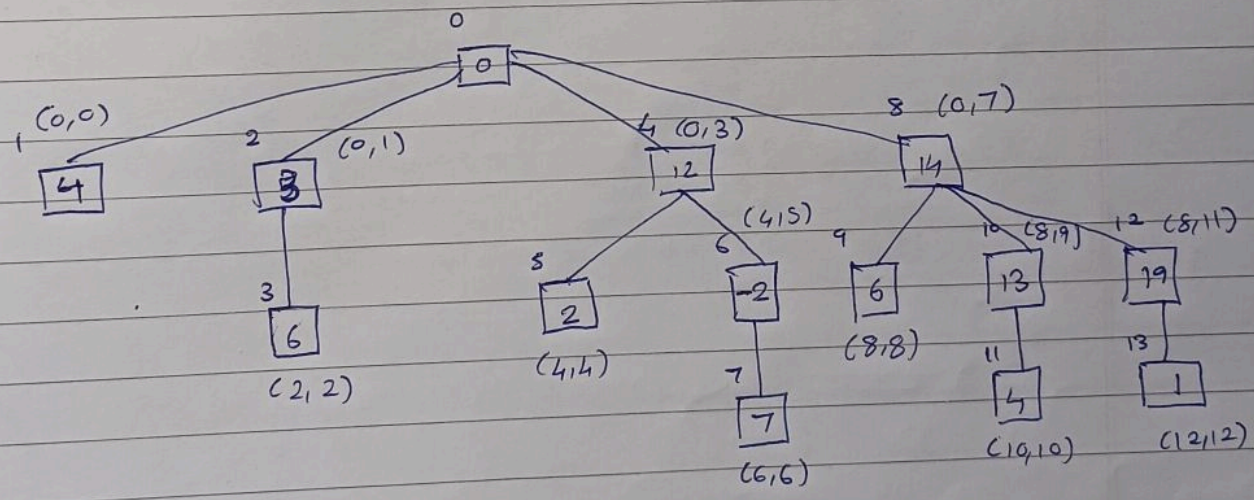


Q

4	-1	6	3	2	-4	7	-3	6	7	4	2	1
0	1	2	3	4	5	6	7	8	9	10	11	12

1) To find Parent Node

1 - - 0
2 - - 0
3 - - 2
4 - - 0
5 - - 4
6 - - 4
7 - - 6
8 - - 0
9 - - 8
10 - - 8
11 - 1011 - 1010 - 10
12 - 1100 - 1000 - 8
13 - 1101 - 1100 - 12



2) Tree Index

1 - (0,0)
2 - (0,1)
3 - (2,2)
4 - (0,3)
5 - (4,4)
6 - (4,5)
7 - (6,6)
8 - (0,7)
9 - (8,8)
10 - (8,9)
11 - $(2^3+2^1)+2^0$ - (10,10)
12 - 2^3+2^2 - (8,11)
13 - $(2^3+2^2)+2^0$ - (12,12)

3) Prefix Sum

pattern 1 : a b c a g a b

Index	0	1	2	3	4	5	6
Pattern	a	b	c	a	g	a	b
~~Ans~~ LPS	0	0	0	1	0	1	2

a a h b c a b a a g

~~0 1 0 0 0 a 2 1 1 0~~

~~0 1 0 0 0 1 0~~

0 1 0 0 0 1 0 1 2 0

LPS 0 1 0 0 0 1 0 1 2 0

a b h g a b c a b h a

LPS 0 0 0 0 1 2 0 1 2 3 1

Test : onionionsgr

pattern : onions