

BINARY SEARCH

- ① Linear Search
- ② Binary Search

Linear Search

$$\underline{T.C = O(n)}$$

target = 2 ✓

arr

4	3	1	2	5	8
0	1	2	3	4	5

↑ ↑ ↑ ↑
~~i~~ ~~i~~ ~~i~~ i

ans = 3
index

arr[3] = target

Binary Search

→ works only on sorted

* sorted

target = 7

arr

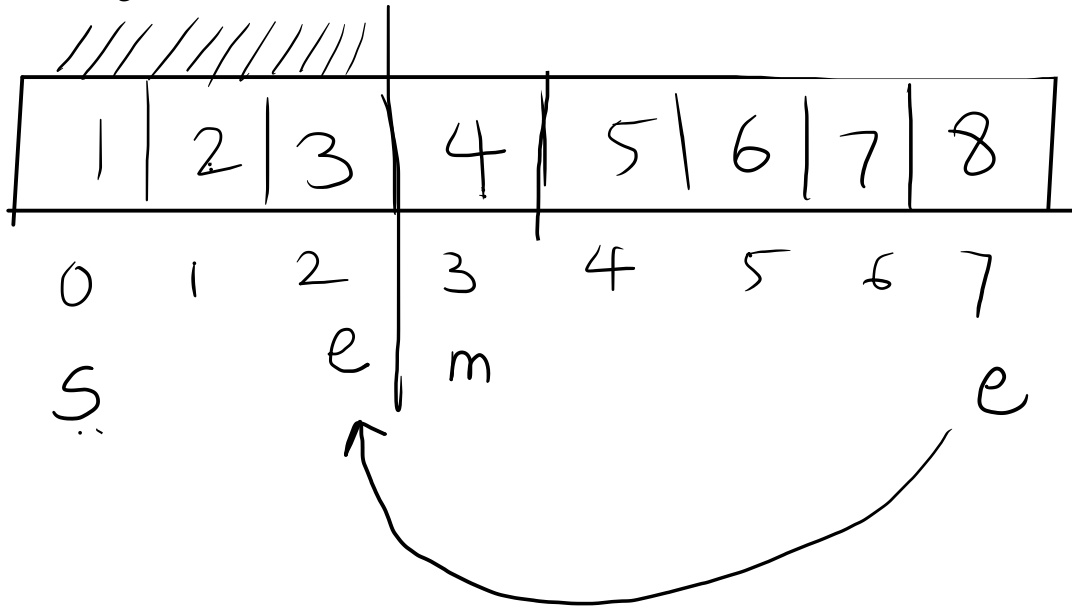
				////////////////////			
1	2	3	4	5	6	7	8
0	1	2	3	4	5	6	7
			m	m+1			e
s				↑			

$$m = \frac{(s+e)}{2}$$

$$\underline{s = m+1}$$

target = 2

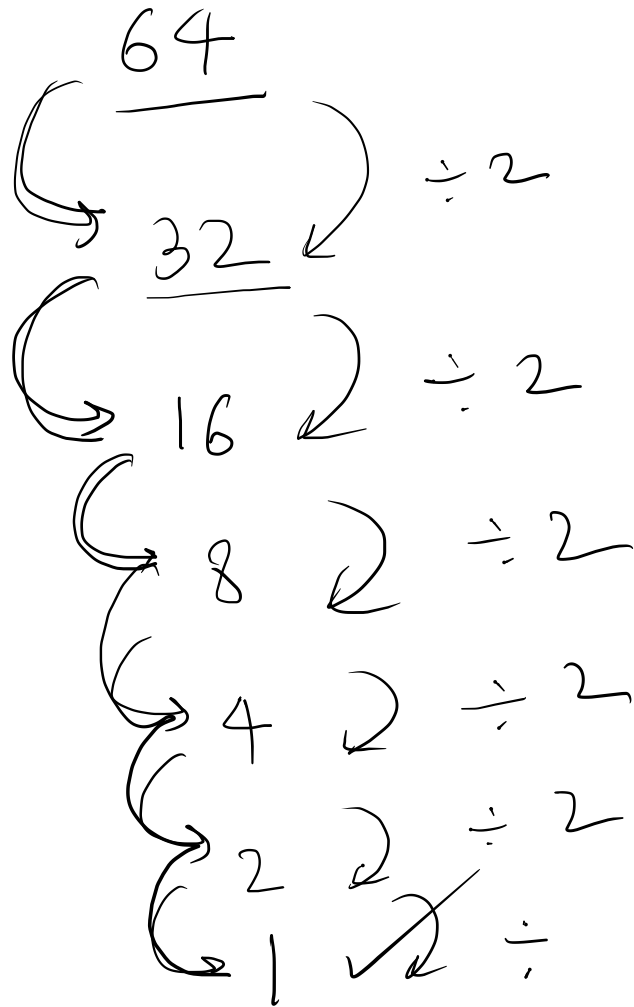
arr



$$e = m - 1$$

Binary Search

$$\underline{T.C = O(\log_2 n)}$$



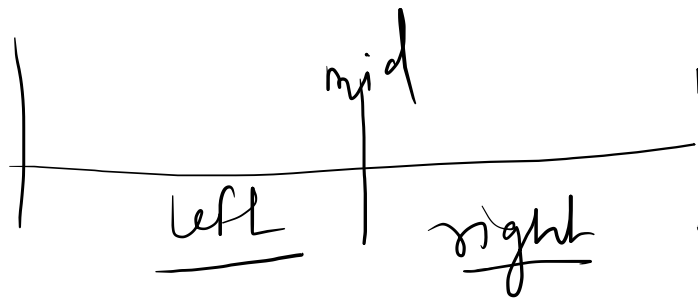
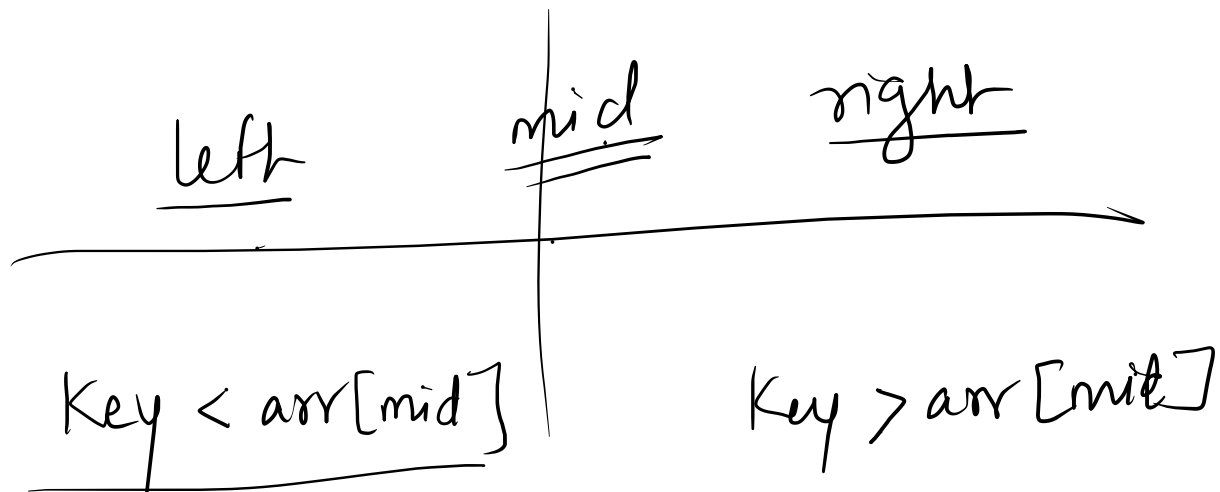
$$\underline{\log_2 64 = 6}$$

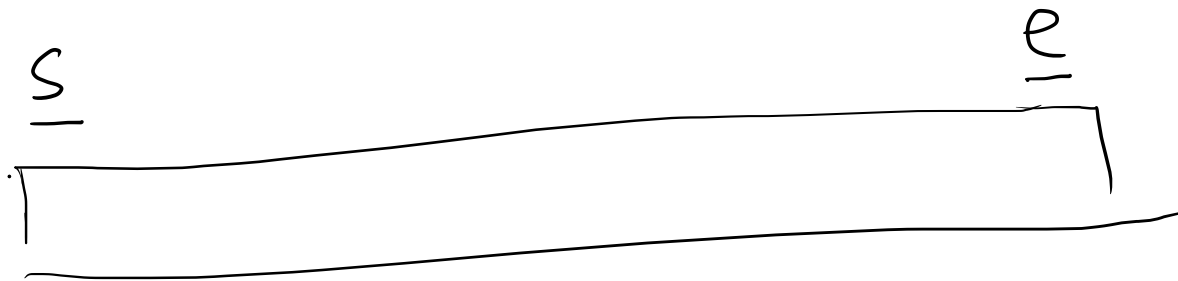
$$\underline{2^{(6)} = 64}$$

$$3^{(2)} = 9$$

$$\underline{\log_2 64 = 6}$$

$$\underline{\log_3 9 = 2}$$





✓✓ $S \leq e$

Search in 2D matrix

X

✓

1	3	5	<u>7</u>
10	11	16	<u>20</u>
23	30	34	<u>60</u>

target = 16

$16 \leq 7$ X

$16 \leq 20$

- ① find the correct row
- ② Apply binary search in that row

Search in 2D matrix

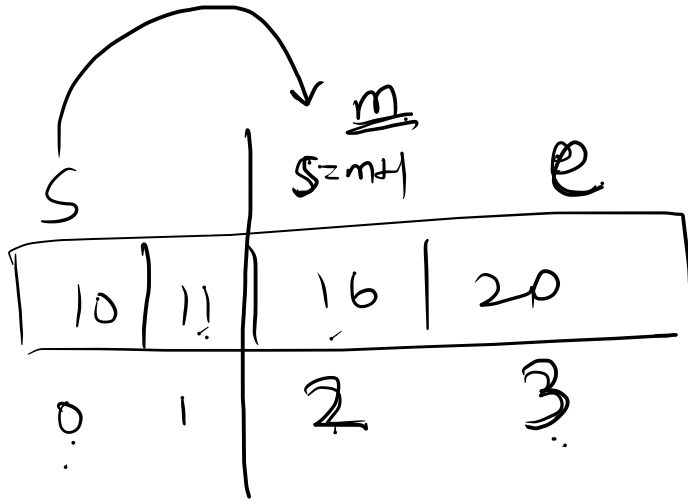
	c1	c2	c3	c4
0 →	1	3	5	<u>7</u> ✗
✓	10	11	16	<u>20</u> ✓
	23	30	34	<u>60</u>

0 1 3 5 7 4

key = 16

Search in 2D matrix

1	3	5	7
10	11	16	20
23	30	34	60



target = 16

$$\underline{m} = \frac{s + e}{2} = \frac{2 + 3}{2} = \frac{5}{2} = 2$$

$$\underline{TC = O(m * \log n)}$$

$$\underline{\text{Auxiliary space} = O(1)}$$

Optimisation

- ① find the correct row
- ② apply binary search

$$\underline{O(\log m \times n)}$$

Search Insert Position

↙
Element present

target = 3

✓

1	2	3	4
0	1	<u>2</u>	3

Output : 2

↘
Element absent

target = 3

↖

1	2	4	5
0	1	<u>2</u>	3

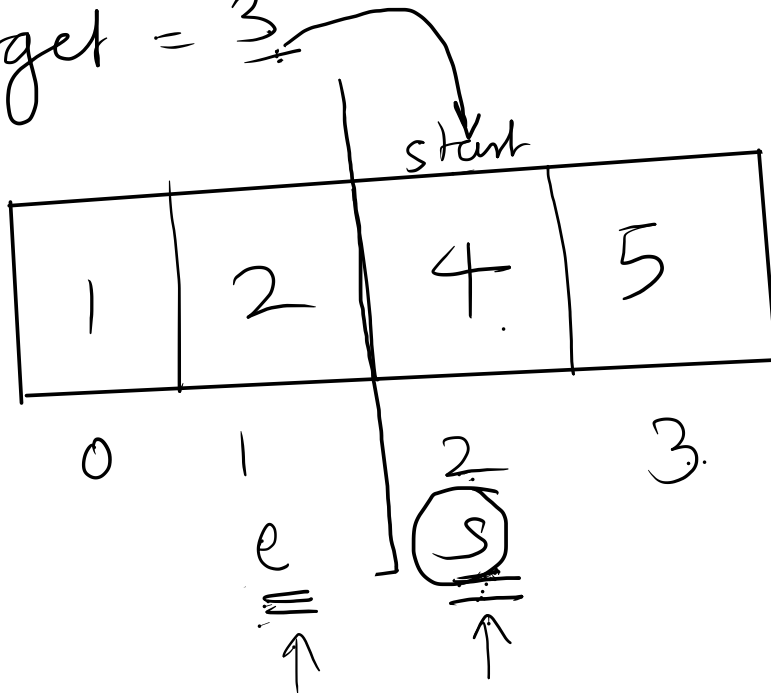
output = 2

Binary Search

$$m = \frac{s+e}{2} = \frac{2+3}{2} = 2$$

$$s = m+1$$

target = 3



$$\underline{\underline{s > e}}$$

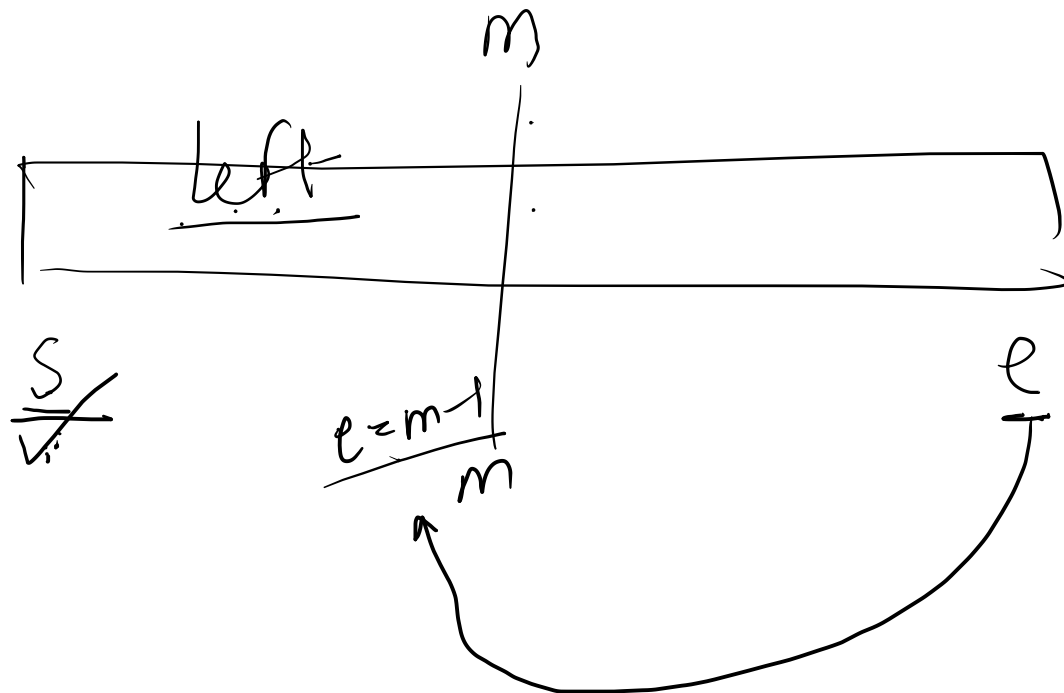
if element is present

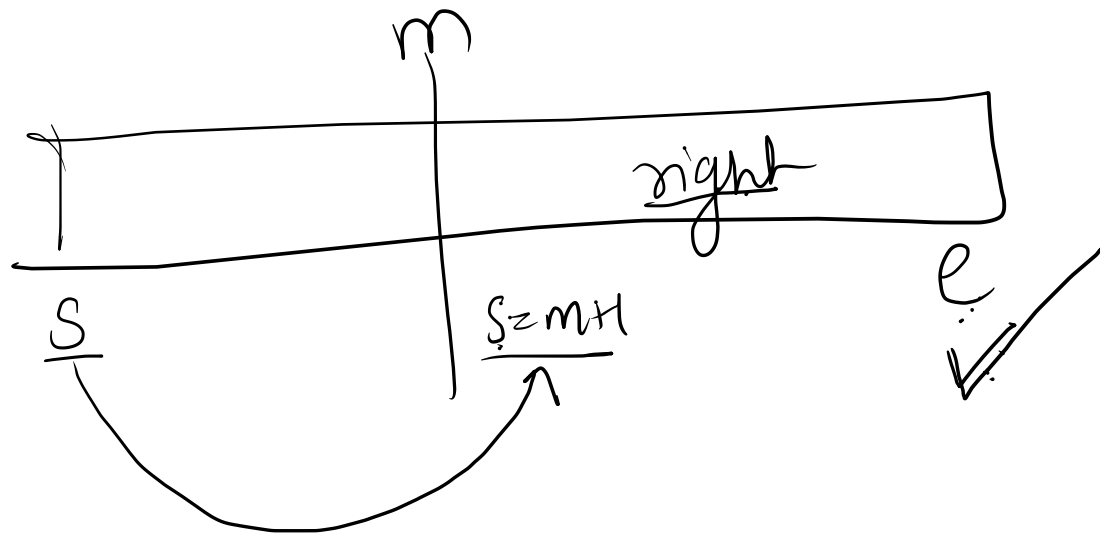
✓ return m. ✓

if element is absent

return s

start





$$\underline{T.C = O(\log n)}$$

$$\underline{\text{Auxiliary space} = O(1)}$$

Sorted Rotated Array

{ 0, 1, 2, 4, 5, 6, 7 }

{ 7, 0, 1, 2, 4, 5, 6 }

{ 6, 7, 0, 1, 2, 4, 5 }

{ 5, 6, 7, 0, 1, 2, 4 }

{ 4, 5, 6, 7, 0, 1, 2 }

$\{4, 5, 6, 7, 0, 1, 2\}$



$\{4, 5, 6, 7\}$



BS

$\{0, 1, 2\}$



BS

{	4	,	5	,	6	,	?	,	0	,	1	,	2	}
	<hr/>													
	0		1		2		3		4		5		6	
	s						m						e	

$\{$

		X	
4,	5,	6,	
0	1	2	

7	X			
8	9	3	3	}
8	9	1	2	
4	5	6	7	
		5	e.	

target = 2

→ find mid

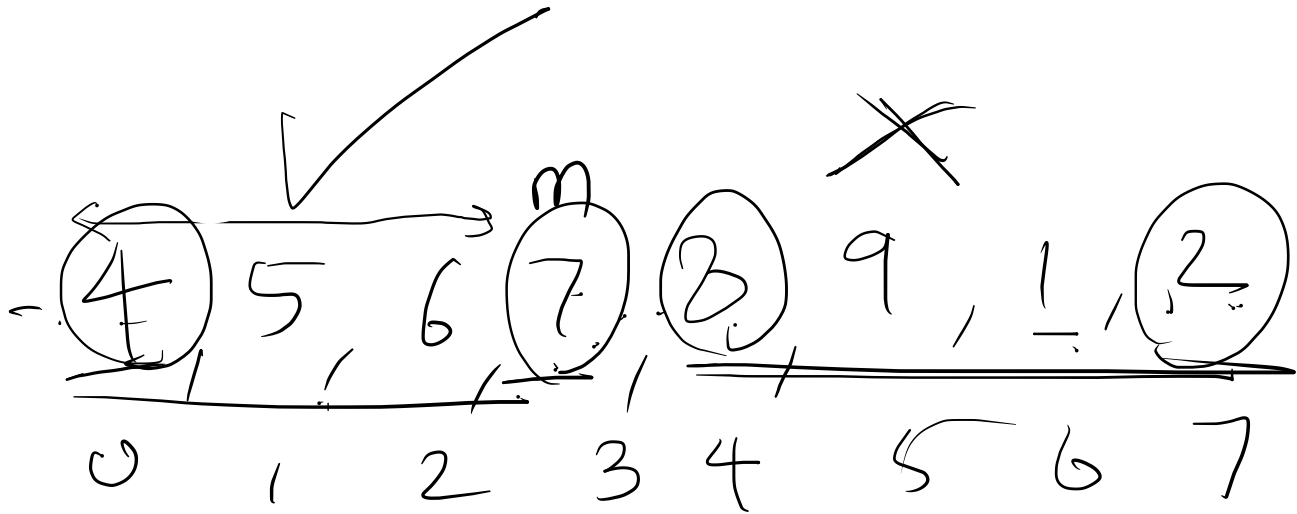
→ check if left / right is sorted
(right)

→ check if element is in range
of right

BS
←————→
sorted
✓

m

sorted



end > start sort

$$TC = O(\log n)$$

$$\text{Auxiliary space} = O(1)$$

$\{1, 2, 3, 4\}$

4 1 2 3

3 4 1 2 →