Practical – 1

Problem Statement: Write a program to determine whether the given numberis Prime or not.

Code:

```
[3] def check_prime(n: int) -> bool:
        if n < 2:
            return False
        for i in range(2, int(n**0.5) + 1):
            if n % i == 0:
                return False
        return True



    n = int(input("Enter a number"))
    if(check_prime(n)):
      print(f"{n} is a prime number")
    else:
      print(f"{n} is not a prime number")
```

```
Enter a number31
31 is a prime number
```

Algorithm Explanation:

1. **Base Case Check**:
   - If nis less than 2, it immediately returns False, because numbers less than 2 are not prime.
2. **Prime Checking Loop**:
   - The function iterates through numbers from 2 up to the square root of n (int(n**0.5) + 1).
   - For each integer iin this range, it checks if nmodulo iequals zero (n % i ==0):
     - If true, nis divisible by iand hence not prime, so it returns False.
     - If no divisors are found in this range, it concludes that nis prime and returns True.
3. **Efficiency**:
   - The loop runs approximately up to sqrt(n)times, which significantly reducesthe number of checks compared to iterating up to n.
   - This makes the function efficient for large values of n.

Time Complexity:

1) Base case check →

* The function starts with a check if $n<2$. This check is $O(1)$ a constant time operation

2) Loop Analysis →

* The loop runs from $i=2$ to $i=\text{int}(\text{sqrt}(n))+1$
* The number of iteration of loop is approx $\sqrt{n}$ because it iterates up to $\sqrt{n}$

3) Inside the loop →

* Each iteration involves a constant-time operation

Total Time complexity →

$$\text{Total} = O(1) + O(\sqrt{n}) \times O(1) = O(\sqrt{n})$$

∴ The time complexity of check-prime function is $O(\sqrt{n})$

Space Complexity:

- **O(1)**: The function uses a constant amount of space.

Practical –2

Problem Statement: Given a sorted array and a target value, return the index if the target is found. If not, return the index where it would be if it were inserted in order.

Code:

```
[13] def search_insert(nums, target):
         left, right = 0, len(nums) - 1

         while left <= right:
             mid = (left + right) // 2
             if nums[mid] == target:
                 return mid
             elif nums[mid] < target:
                 left = mid + 1
             else:
                 right = mid - 1

         return left
```

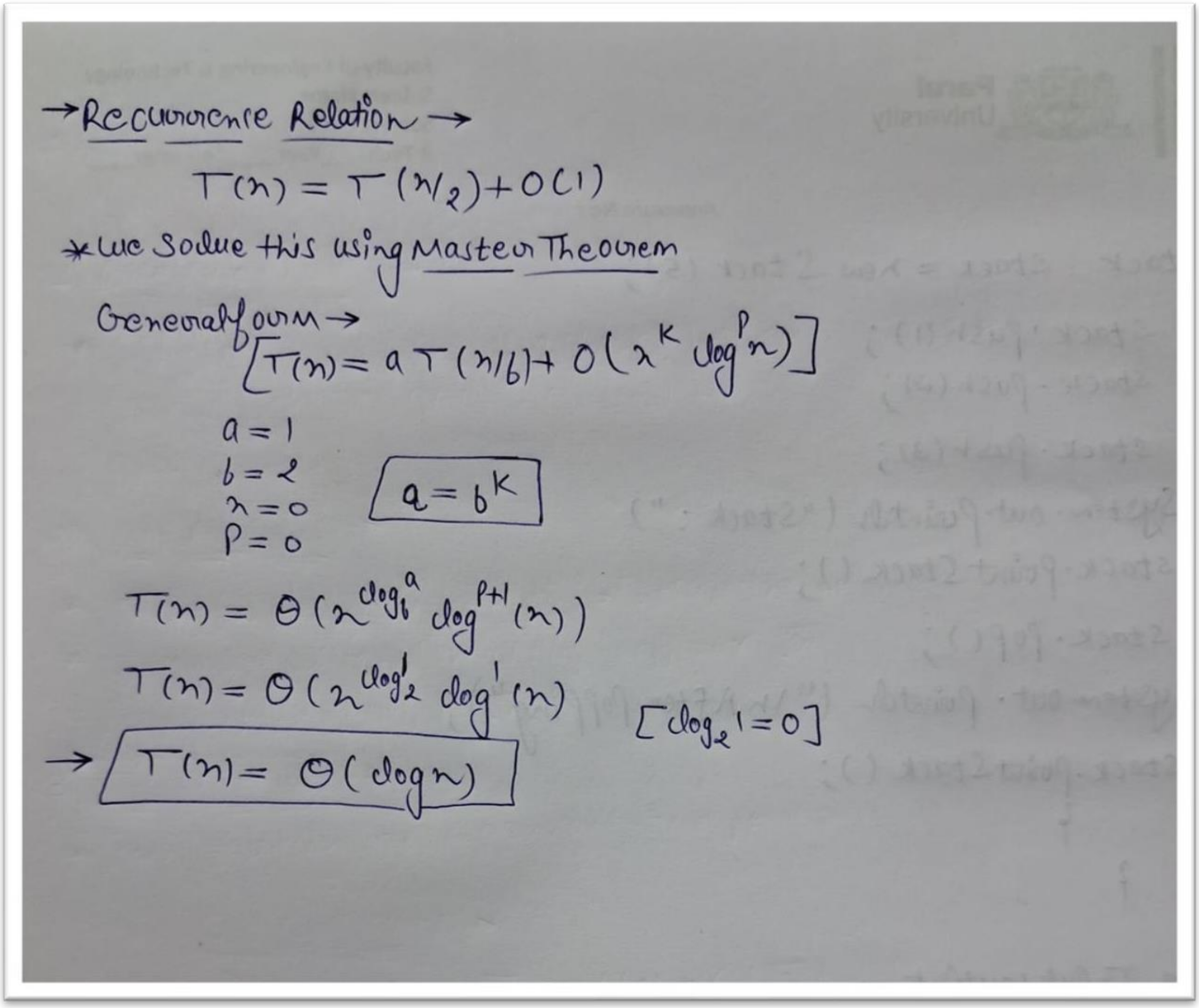
```
[17] nums = [1, 3, 5, 6]
     target = 5
     print(f"The index of {target} is {search_insert(nums, target)}")
     target = 4
     print(f"The index of {target} is {search_insert(nums, target)}")
```

```
The index of 5 is 2
The index of 4 is 2
```

Algorithm Explanation:

- Initialize two pointers, **left** and **right**, to the start and end of the array respectively (left = 0, right = len(nums) - 1).
- While left is less than or equal to right:
  - Calculate the middle index mid as mid = (left + right) // 2.
  - Compare the middle element nums[mid] with target:
    - If nums[mid] == target, return mid (target found).
    - If nums[mid] < target, move the left pointer to mid + 1 (search in the right half).
    - If nums[mid] > target, move the right pointer to mid - 1 (search in the left half).
- If the loop exits without finding the target (left > right), return the left pointer which indicates the insertion point.

<u>Time Complexity</u>:



→ Recurrence Relation →

$$T(n) = T(n/2) + O(1)$$

* We solve this using Master Theorem

General form →

$$[T(n) = aT(n/b) + O(n^k \log^p n)]$$

$a = 1$

$b = 2$

$n = 0$

$p = 0$

$$\boxed{a = b^k}$$

$$T(n) = \Theta(n^{\log_b a} \log^{p+1}(n))$$

$$T(n) = \Theta(n^{\log_2 1} \log^1(n)) \quad [\log_2 1 = 0]$$

$$\rightarrow \boxed{T(n) = \Theta(\log n)}$$

Time Complexity = O(log n)

<u>Space Complexity</u>: O(1) since we use only a constant amount of extra space

Practical – 3

Problem Statement: There are n children standing in a line. Each child is assigneratingvalue given in the integer array ratings.
You are giving candies to these children subjected to the

- Each child must have at least one candy
- Children with a higher rati

Return the minim
the

Code:

```python
def min_candies(ratings):
    n = len(ratings)
    if n == 0:
        return 0

    candies = [1] * n


    for i in range(1, n):
        if ratings[i] > ratings[i-1]:
            candies[i] = candies[i-1] + 1


    for i in range(n-2, -1, -1):
        if ratings[i] > ratings[i+1]:
            candies[i] = max(candies[i], candies[i+1] + 1)


    total_candies = sum(candies)

    return total_candies
```

```python
ratings = [1, 0, 2]
print(f"The total number of candies required is {min_candies(ratings)}")
```

```
The total number of candies required is 5
```

Algorithm Explanation:

1. **Initialization**:
   - Create an array candies initialized to all ones, as each child must receive at least one candy initially.
2. **First Pass (Left to Right)**:
   - Traverse the ratings array from left to right.
   - If a child's rating is greater than the previous child's rating (ratings[i] > ratings[i-1]), assign candies[i] = candies[i-1] + 1. This ensures that a child with a higher rating gets more candies than the previous child.
3. **Second Pass (Right to Left)**:
   - Traverse the ratings array from right to left.

- Adjust the candies count for each child again:
- If a child's rating is greater than the next child's rating (ratings[i] > ratings[i+1]) and the current candies count (candies[i] <= candies[i+1]), update candies[i] to ensure that the child with higher rating gets more candies than the next child.

4. **Compute Total Candies**:
   - Sum up all the values in the candies array to get the total minimum number of candies needed.

Time Complexity:

1) Initialization →

Candies = [1] * n

$T(n) = O(n)$

2) Left to Right loop →

The loop for i in range(1, n)

rating[i] > rating[i-1] → $O(1)$

Since this loop runs from 1 to (n-1)

$T(n) = O(n-1)$

$= O(n)$

3) Right to Left →

for i in range(n-2, -1, -1)

This also runs (n-1)

$T(n) = O(n)$

4) Sum →

Summing up to n

$T(n) = O(n)$

Total $T(n) = O(n) + O(n) + O(n) + O(n)$

$= O(n)$

Space Complexity:

- **Input Size**: The ratings array of size n requires O(n) space.
- **Candies Array**: An additional array candies of size n is used totrack candies given to each child, also requiring O(n) space.
- **Additional Variables**: Variables like n, loop counters (i), and temporary variables (ratings[i], ratings[i-1], ratings[i+1]) occupy constant O(1) space.
- **Total Space Complexity**: Combining the above, the total space complexity is **O(n),** where n is the number of children (length of the ratings array).