



Experiment 5.1

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- 1. Aim:** Find the k most frequent elements in an array. Use a hash map to count frequencies, then use a min-heap or bucket sort to extract the top k elements. The heap approach runs in $O(n \log k)$ time. Edge cases include $k = 1$ or all elements being unique.
- 2. Objective:** Implement an algorithm to identify and return the k most frequently occurring elements within a given array.
- 3. Implementation/Code:**

```
class Solution {
public:
    vector<int> topKFrequent(vector<int>& nums, int k) {
        unordered_map<int,int> mp;
        int n=nums.size();
        for(int i=0;i<n;i++){
            mp[nums[i]]++;
        }
        vector<pair<int,int>> freq(mp.begin(),mp.end());
        sort(freq.begin(), freq.end(), [](auto &a, auto &b) {
            return a.second > b.second;
        });
        vector<int> ans;

        for(int i=0;i<k;i++){
            ans.push_back(freq[i].first);
        }

        return ans;
    }
};
```

4. Output



```
Accepted Runtime: 0 ms
• Case 1 • Case 2
Input
nums =
[1, 1, 1, 2, 2, 3]
k =
2
Output
[1, 2]
```

5. Learning Outcomes

- Understand the concept of hash maps and min-heaps.
- Learnt how to implement the algorithm in a programming language.
- Learnt how to evaluate and compare the min-heap and bucket sort approaches for top-k extraction.
- Understand the importance of code efficiency, and how to create code that runs within the desired time constraints.

Experiment 5.2

1. **Aim:** Find the kth largest element in an array using a min-heap or Quickselect. The heap approach runs in $O(n \log k)$ time, while Quickselect runs in $O(n)$ on average. Edge cases include $k = 1$ (max element) and $k = n$ (min element).
2. **Objective:** Implement algorithms to efficiently find the kth largest element within a given array.

3. Code:

```
class Solution {
public:
    int findKthLargest(vector<int>& nums, int k) {
```

```
priority_queue<int> max;
int a=1;
for(auto p:nums){
    max.push(p);
}
for(int i=0;i<nums.size();i++){
    if(a<k){
        max.pop();
        a++;
    }
}
return max.top();
}
```

4. Output

Accepted Runtime: 0 ms

• Case 1 • Case 2

Input

nums =
[3,2,1,5,6,4]

k =
2

Output

5

5. Learning Outcomes:

- Understand the steps involved in both the min-heap and Quickselect algorithms for finding the kth largest element.
- Learn how to analyze and compare the time complexity of the min-heap ($O(n \log k)$) and Quickselect ($O(n)$ average) approaches.
- Implement both the min-heap and Quickselect algorithms in a programming language.

Experiment 5.3

1. **Aim:** Find the kth smallest element in a row- and column-sorted matrix. Use a min-heap ($O(k \log n)$) or binary search on values ($O(n \log \max\text{-min})$). Edge cases include $k = 1$ (smallest element) and $k = n^2$ (largest element).
2. **Objective:** Implement an algorithm to find the kth smallest element using binary search on values.

3. Code:

```
class Solution
{
public:
    int kthSmallest(vector<vector<int>>& matrix, int k)
    {
        int n = matrix.size();
        int le = matrix[0][0], ri = matrix[n - 1][n - 1];
        int mid = 0;
        while (le < ri)
        {
            mid = le + (ri-le)/2;
            int num = 0;
            for (int i = 0; i < n; i++)
            {
                int pos = upper_bound(matrix[i].begin(), matrix[i].end(), mid) -
matrix[i].begin();
                num += pos;
            }
            if (num < k)
            {
                le = mid + 1;
            }
            else
            {
                ri = mid;
            }
        }
        return le;
    }
};
```



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4. Output

```
Accepted Runtime: 0 ms
• Case 1 • Case 2
Input
matrix =
[[1,5,9],[10,11,13],[12,13,15]]
k =
8
Output
13
```

5. Learning Outcomes:

- Understand the steps involved in both the min-heap and binary search algorithms.
- Learn how to analyze and compare the time complexity.
- Implement appropriate algorithm based on the problem's constraints.