Name: Khushi Nitinkumar Patel
PRN: 2020BTECS00037
Batch: T5

Design and analysis of algorithm Lab

Week 2 Assignment

Part 2: Sorting Algorithm

Q) Given an array A[0…n-1] of n numbers containing repetition of some number. Given an algorithm for checking whether there are repeated element or not. Assume that we are not allowed to use additional space (i.e., we can use a few temporary variable, O(1) storage).

> Algorithm:

1. Traverse the given array from start to end.

2. For every element in the array increment the arr[i]%n‘th element by n.

3. Now traverse the array again and print all those indexes i for which

arr[i]/n is greater than 1. Which guarantees that the number n has been added to

that index

4. This approach works because all elements are in the range from 0 to n-1

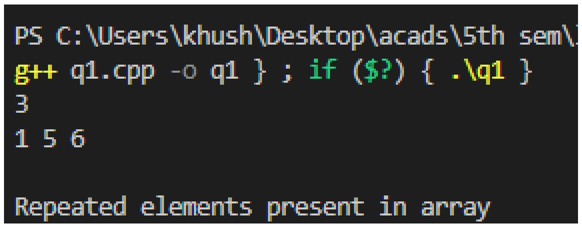
and arr[i] would be greater than n only if a value “i” has appeared more than

once.

Code:

```cpp
#include <bits/stdc++.h>
using namespace std;
int main()
{
    int n;
    cin >> n;
    int arr[n];
    for (int i = 0; i < n; i++)
    {
        cin >> arr[i];
    }
    // 1 6 3 1 3 6 6
    for (int i = 0; i < n; i++)
    {
        if (arr[arr[i] % n] > 0)
        {
            arr[arr[i] % n] = arr[arr[i] % n] + n;
        }
    }
    bool ans = false;
    for (int i = 0; i < n; i++)
    {
        if (arr[i] >= n * 2)
        {
            // cout<<i<<" ";
            ans = true;
        }
    }
    cout << endl;
    if (ans == true)
    {
        cout << "Repeated elements present in array" << endl;
    }
    else
    {
        cout << "Repeated elements not present in array" << endl;
    }
}
```

Output:



```
PS C:\Users\khush\Desktop\acads\5th sem\
g++ q1.cpp -o q1 } ; if ($?) { .\q1 }
3
1 5 6

Repeated elements present in array
```

Time complexity: O(n)

Space complexity: O(1)

Q) Given an array A[0…n-1] , where each element of the array represents a vote in the election. Assume that each vote is given as an integer representing the ID of the chosen candidate. Given an algorithm for determining who wins the election.

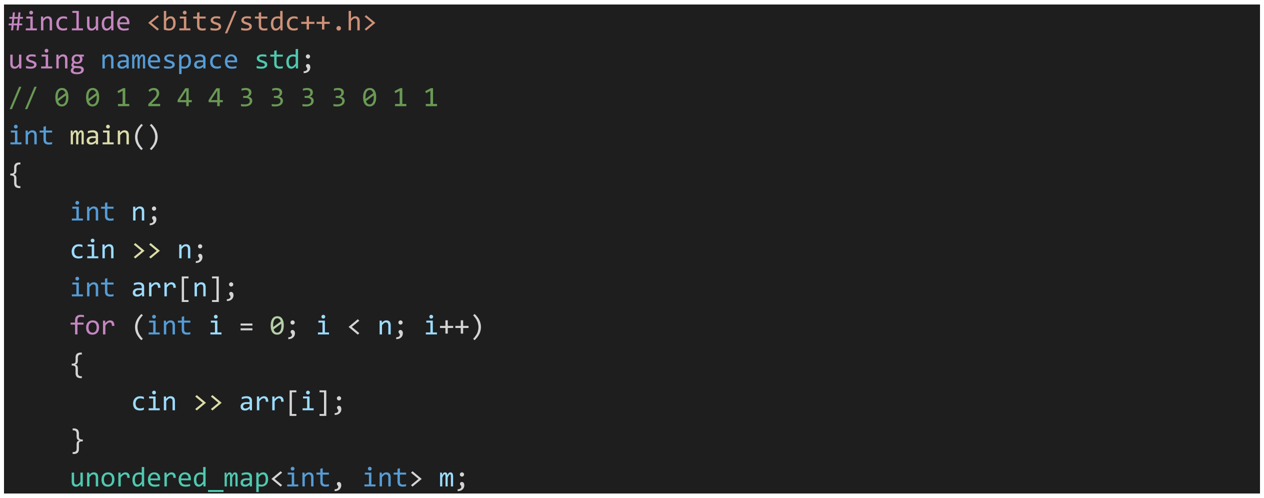
> Algorithm:

1. Create unordered_map m

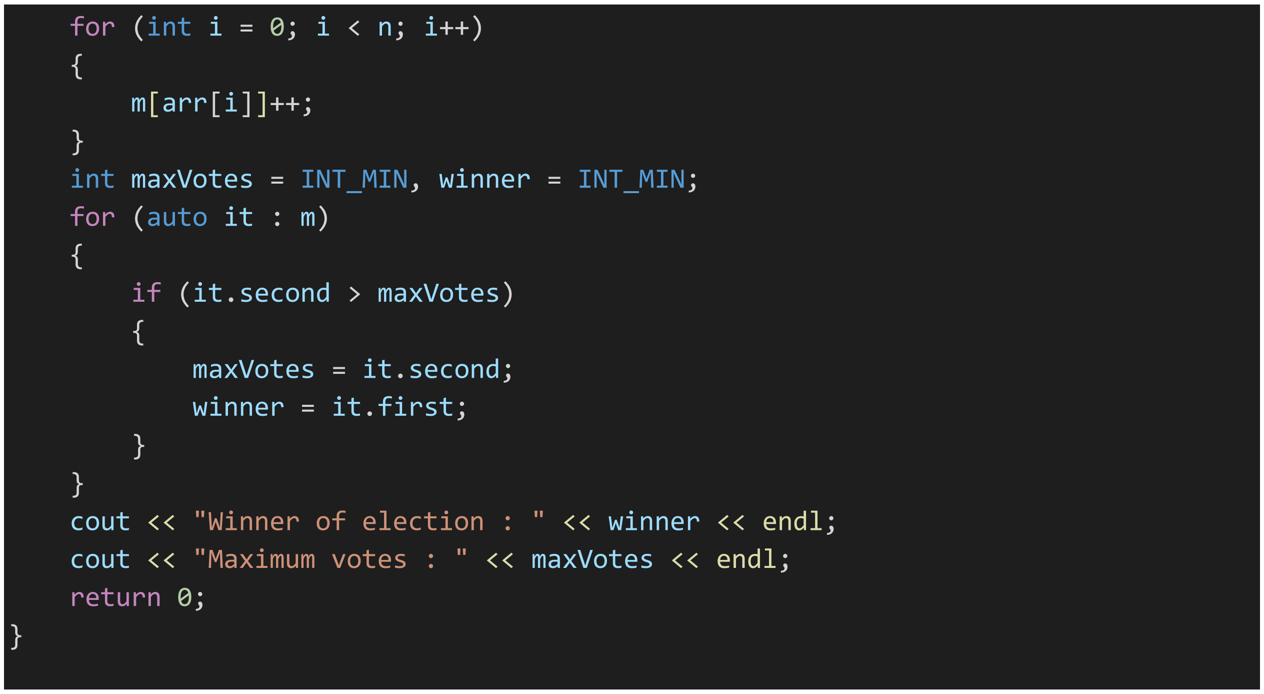
2. Store frequency of voters

3. Search for maximum votes that is the winner.

Code:

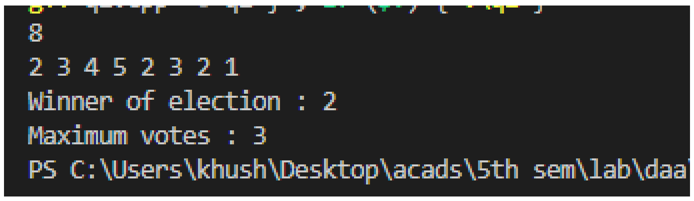


```cpp
#include <bits/stdc++.h>
using namespace std;
// 0 0 1 2 4 4 3 3 3 3 0 1 1
int main()
{
    int n;
    cin >> n;
    int arr[n];
    for (int i = 0; i < n; i++)
    {
        cin >> arr[i];
    }
    unordered_map<int, int> m;
```



```cpp
    for (int i = 0; i < n; i++)
    {
        m[arr[i]]++;
    }
    int maxVotes = INT_MIN, winner = INT_MIN;
    for (auto it : m)
    {
        if (it.second > maxVotes)
        {
            maxVotes = it.second;
            winner = it.first;
        }
    }
    cout << "Winner of election : " << winner << endl;
    cout << "Maximum votes : " << maxVotes << endl;
    return 0;
}
```

Output:



```
8
2 3 4 5 2 3 2 1
Winner of election : 2
Maximum votes : 3
PS C:\Users\khush\Desktop\acads\5th sem\lab\daa
```

Time complexity: O(n)

Space Complexity: O(n)

Q) Given an array A of n elements, each of which is an integer in the range 1, n^2]. How do we sort the array in O(n) time?

We can sort elements by using radix sort in O(n) time with some constant space.

> Algorithm:

1. Find the maximum element of the array, let it be max

2. Find the number of digits in max let it be k

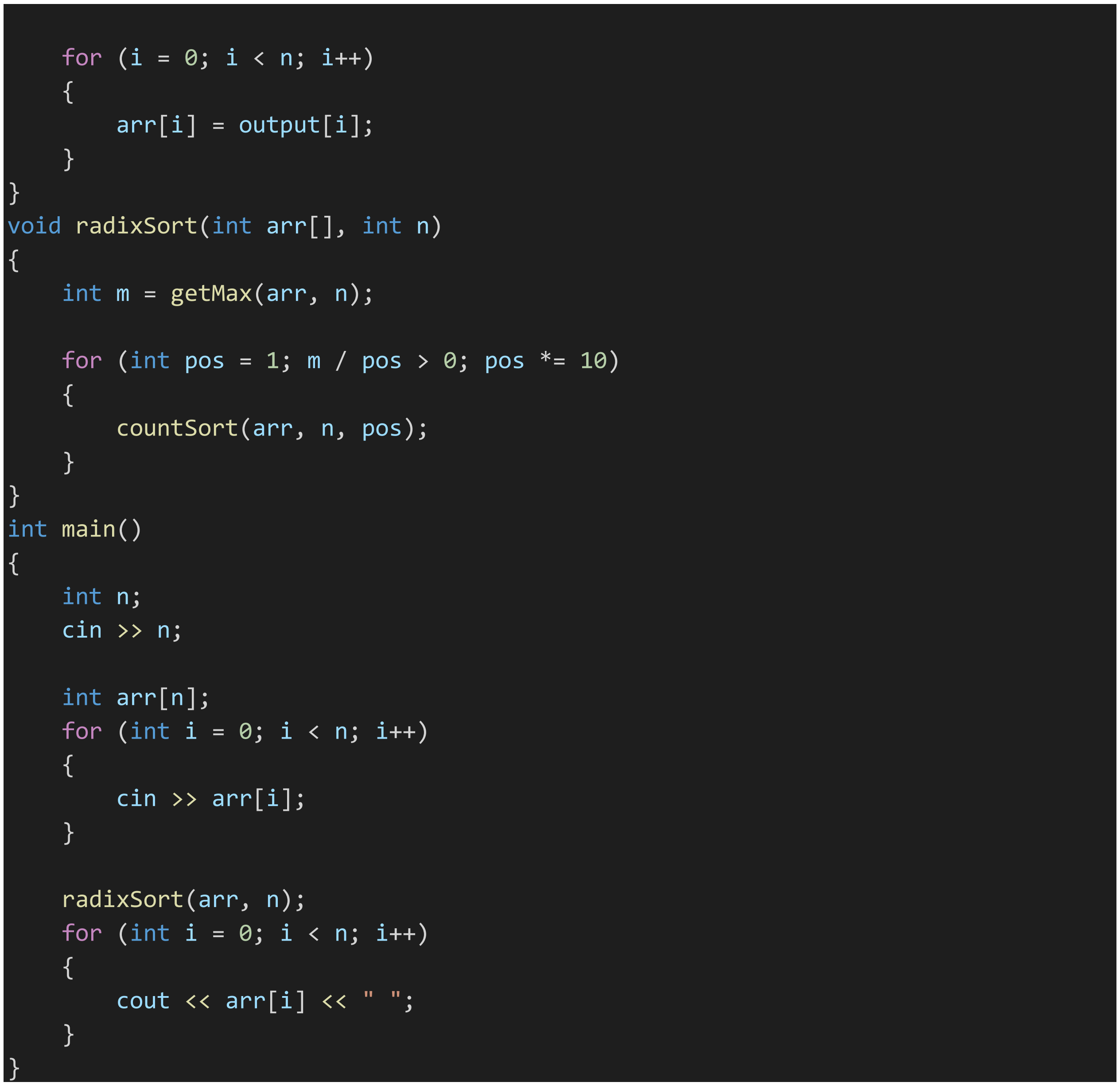
3. For each, i ranging from 1 to k, apply the counting sort algorithm for the ith

least significant digit of each element. If any element has less than i digits

consider 0 at its place

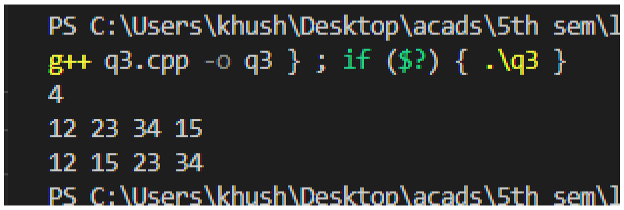
Code:

```
#include <iostream>
using namespace std;
int getMax(int arr[], int n)
{
    int k = arr[0];
    for (int i = 0; i < n; i++)
    {
        k = max(k, arr[i]);
    }
    return k;
}
void countSort(int arr[], int n, int pos)
{
    int output[n], i;
    int count[10] = {0};

    for (i = 0; i < n; i++)
    {
        count[(arr[i] / pos) % 10]++;
    }

    for (i = 1; i < 10; i++)
    {
        count[i] += count[i - 1];
    }

    for (i = n - 1; i >= 0; i--)
    {
        output[--count[(arr[i] / pos) % 10]] = arr[i];
    }
```



```cpp
    for (i = 0; i < n; i++)
    {
        arr[i] = output[i];
    }
}
void radixSort(int arr[], int n)
{
    int m = getMax(arr, n);

    for (int pos = 1; m / pos > 0; pos *= 10)
    {
        countSort(arr, n, pos);
    }
}
int main()
{
    int n;
    cin >> n;

    int arr[n];
    for (int i = 0; i < n; i++)
    {
        cin >> arr[i];
    }

    radixSort(arr, n);
    for (int i = 0; i < n; i++)
    {
        cout << arr[i] << " ";
    }
}
```

Output:



```
PS C:\Users\khush\Desktop\acads\5th sem\
g++ q3.cpp -o q3 } ; if ($?) { .\q3 }
4
12 23 34 15
12 15 23 34
PS C:\Users\khush\Desktop\acads\5th sem\
```

Time Complexity: O(n)

Space Complexity: O(n)

Q) Let A and B two arrays of n elements, each. Given a number K, give an O (nlogn) time algorithm for determining whether there exists a ϵ A and b ϵ B such that a+b =K.

> Algorithm:

1. Sort the given two arrays using sorting algorithm of time complexity

O(nlogn)

2. Traverse array A and search for element K-A[i] in array B, using Binary

search.

3. If element found then return true, elese search for other pair of elements.

HeapSort:

1. Build a max heap from the input data.

2. At this point, the maximum element is stored at the root of the heap.

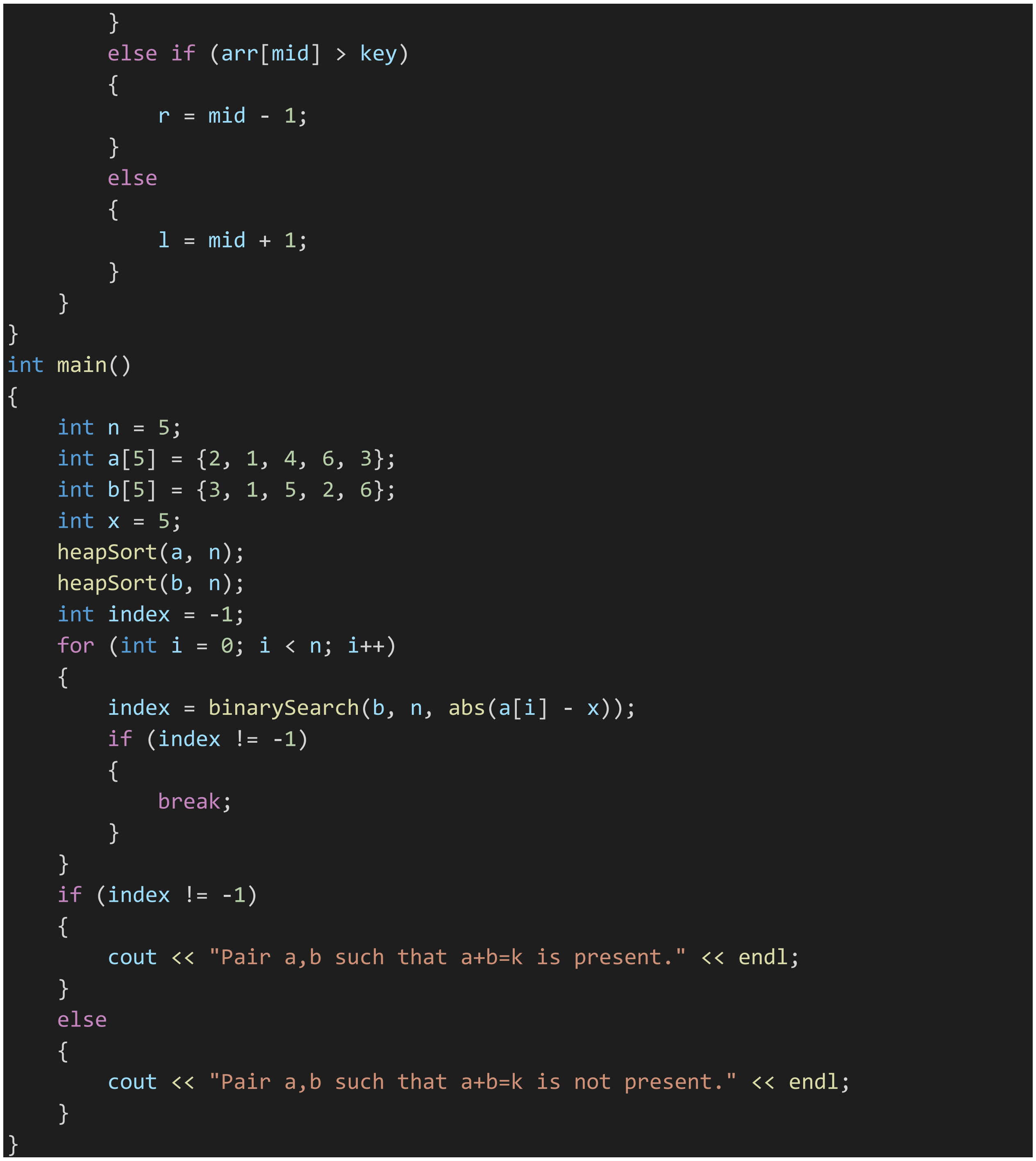
Replace it with the last item of the heap followed by reducing the size of the

heap by 1. Finally, heapify the root of the tree.

3. Repeat step 3 while the size of the heap is greater than 1.

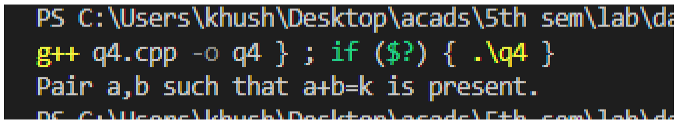
Code:

```
#include <bits/stdc++.h>
using namespace std;
void heapify(int arr[], int n, int i)
{
    int largest = i;
    int l = 2 * i;
    int r = 2 * i + 1;

    if (l < n && arr[l] > arr[largest])
        largest = l;
    if (r < n && arr[r] > arr[largest])
        largest = r;

    if (largest != i)
    {
        swap(arr[i], arr[largest]);

        heapify(arr, n, largest);
    }
}
void heapSort(int arr[], int n)
{
    for (int i = n / 2 - 1; i >= 0; i--)
    {
        heapify(arr, n, i);
    }

    for (int i = n - 1; i > 0; i--)
    {
        swap(arr[0], arr[i]);

        heapify(arr, i, 0);
    }
}
int binarySearch(int arr[], int n, int key)
{
    int l = 0, r = n;
    while (l <= r)
    {
        int mid = (l + r) / 2;
        if (arr[mid] == key)
        {
            return mid;
```



```cpp
        }
        else if (arr[mid] > key)
        {
            r = mid - 1;
        }
        else
        {
            l = mid + 1;
        }
    }
}
int main()
{
    int n = 5;
    int a[5] = {2, 1, 4, 6, 3};
    int b[5] = {3, 1, 5, 2, 6};
    int x = 5;
    heapSort(a, n);
    heapSort(b, n);
    int index = -1;
    for (int i = 0; i < n; i++)
    {
        index = binarySearch(b, n, abs(a[i] - x));
        if (index != -1)
        {
            break;
        }
    }
    if (index != -1)
    {
        cout << "Pair a,b such that a+b=k is present." << endl;
    }
    else
    {
        cout << "Pair a,b such that a+b=k is not present." << endl;
    }
}
```

Output:



```
PS C:\Users\khush\Desktop\acads\5th sem\lab\da
g++ q4.cpp -o q4 } ; if ($?) { .\q4 }
Pair a,b such that a+b=k is present.
```

Time Complexity: O(nlogn)

Space Complexity: O(1)