Array Rotation

Given an array of integers **arr[]** of size **N** and an integer, the task is to rotate the array elements to the **left** by **d** positions.

Examples:

```
Input:arr[] = {1, 2, 3, 4, 5, 6, 7}, d = 2Output: 3 4 5 6 7
1 2Input:arr[] = {3, 4, 5, 6, 7, 1, 2}, d=2Output: 5 6 7 1
2 3 4
```

Approach 1 (Using temp array): This problem can be solved using the below idea:

> After rotating d positions to the left, the first d elements become the last d elements of the array
>
> - *First store the elements from index **d** to **N-1** into the temp array.*
> - *Then store the first **d** elements of the original array into the temp array.*
> - *Copy back the elements of the temp array into the original array*

Illustration:

> Suppose the give array is arr[] = [1, 2, 3, 4, 5, 6, 7], d = 2.
>
> ***First Step:***
>
> *=> Store the elements from 2nd index to the last.*
>
> => ***temp[] = [3, 4, 5, 6, 7]***
>
> ***Second Step:***
>
> *=> Now store the first 2 elements into the temp[] array.*
>
> => ***temp[] = [3, 4, 5, 6, 7, 1, 2]***
>
> ***Third Steps:***

> *=> Copy the elements of the temp[] array into the original array.*
>
> *=>* ***arr[] = temp[]*** *So* ***arr[] = [3, 4, 5, 6, 7, 1, 2]***

Follow the steps below to solve the given problem

- Initialize a temporary array(**temp[n]**) of length same as the original array
- Initialize an integer(**k**) to keep a track of the current index
- Store the elements from the position **d** to **n-1** in the temporary array
- Now, store **0** to **d-1** elements of the original array in the temporary array
- Lastly, copy back the temporary array to the original array

Below is the implementation of the above approach :

```
#include <bits/stdc++.h>
using namespace std;

// Function to rotate array
void Rotate(int arr[], int d, int n)
{
    // Storing rotated version of array
    int temp[n];

    // Keeping track of the current index   // of temp[]
    int k = 0;

    // Storing the n - d elements of
    // array arr[] to the front of temp[]
    for (int i = d; i < n; i++) {
        temp[k] = arr[i];
        k++;
    }

    // Storing the first d elements of array arr[]
    // into temp
    for (int i = 0; i < d; i++) {
        temp[k] = arr[i];
        k++;
```

```
    }

    // Copying the elements of temp[] in arr[]
    // to get the final rotated array
    for (int i = 0; i < n; i++) {
        arr[i] = temp[i];
    }
}

// Function to print elements of array
void PrintTheArray(int arr[], int n)
{
    for (int i = 0; i < n; i++) {
        cout << arr[i] << " ";
    }
}

// Driver code
int main()
{
    int arr[] = { 1, 2, 3, 4, 5, 6, 7 };
    int N = sizeof(arr) / sizeof(arr[0]);
    int d = 2;

    // Function calling Rotate(arr, d, N);
    PrintTheArray(arr, N);

    return 0;
}
```

Output

```
3 4 5 6 7 1 2
```

Time complexity: O(N)

Auxiliary Space: O(N)

Approach 2 (Rotate one by one): This problem can be solved using the below idea:

> At each iteration, shift the elements by one position to the left circularly (i.e., first element becomes the last).Perform this operation d times to rotate the elements to the left by d position.

Illustration:

> Let us take arr[] = [1, 2, 3, 4, 5, 6, 7], d = 2.
>
> ***First Step:***
>
> *=> Rotate to left by one position.*
>
> *=>* ***arr[] = {2, 3, 4, 5, 6, 7, 1}***
>
> ***Second Step:***
>
> *=> Rotate again to left by one position*
>
> *=>* ***arr[] = {3, 4, 5, 6, 7, 1, 2}***
>
> *Rotation is done by 2 times.*
>
> *So the array becomes* ***arr[] = {3, 4, 5, 6, 7, 1, 2}***

Follow the steps below to solve the given problem.

- Rotate the array to left by one position. For that do the following:
  - Store the first element of the array in a temporary variable.
  - Shift the rest of the elements in the original array by one place.
  - Update the last index of the array with the temporary variable.
- Repeat the above steps for the number of left rotations required.

Below is the implementation of the above approach:

```
// C++ program to rotate an array by
// d elements
#include <bits/stdc++.h>
using namespace std;

/*Function to left rotate arr[] of size n by d*/
```

```
void Rotate(int arr[], int d, int n)
{
    int p = 1;
    while (p <= d) {
        int last = arr[0];
        for (int i = 0; i < n - 1; i++) {
            arr[i] = arr[i + 1];
        }
        arr[n - 1] = last;
        p++;
    }
}

// Function to print an arrayvoid
printArray(int arr[], int size)
{
    for (int i = 0; i < size; i++)
        cout << arr[i] << " ";
}

// Driver code
int main()
{
    int arr[] = { 1, 2, 3, 4, 5, 6, 7 };
    int N = sizeof(arr) / sizeof(arr[0]);
    int d = 2;

    // Function calling Rotate(arr, d, N);
    printArray(arr, N);

    return 0;
}
```

Output

```
3 4 5 6 7 1 2
```

Time Complexity: O(N * d)

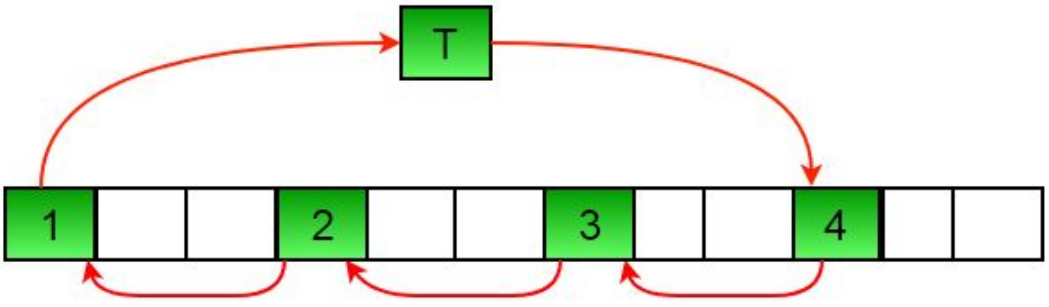
Auxiliary Space: O(1)

Approach 3 (A Juggling Algorithm): This is an extension of method 2.

> Instead of moving one by one, divide the array into different sets where the number of sets is equal to the GCD of N and d (say X. So the elements which are X distance apart are part of a set) and rotate the elements within sets by 1 position to the left.
>
> - *Calculate the GCD between the length and the distance to be moved.*
> - *The elements are only shifted within the sets.*
> - *We start with temp = arr[0] and keep moving arr[I+d] to arr[I] and finally store temp at the right place.*

Follow the below illustration for a better understanding

Illustration:

> Each steps looks like following:
>
> 
>
>
> *Let* ***arr[] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14}*** *and* ***d = 10***
>
> ***First step:***
>
> *=> First set is* ***{0, 5, 10}.***
>
> *=> Rotate this set by d position in cyclic order*

=> arr[0] = arr[0+10]

=> arr[10] = arr[(10+10)%15]

=> arr[5] = arr[0]

*=> This set becomes **{10,0,5}***

*=> Array **arr[] = {10, 1, 2, 3, 4, 0, 6, 7, 8, 9, 5, 11, 12, 13, 14}***

Second step:

*=> Second set is **{1, 6, 11}.***

=> Rotate this set by d position in cyclic order.

*=> This set becomes **{11, 1, 6}***

*=> Array arr[] = **{10, 11, 2, 3, 4, 0, 1, 7, 8, 9, 5, 6, 12, 13, 14}***

Third step:

*=> Second set is **{2, 7, 12}.***

=> Rotate this set by d position in cyclic order.

*=> This set becomes **{12, 2, 7}***

*=> Array **arr[] = {10, 11, 12, 3, 4, 0, 1, 2, 8, 9, 5, 6, 7, 13, 14}***

Fourth step:

*=> Second set is **{3, 8, 13}.***

=> Rotate this set by d position in cyclic order.

*=> This set becomes **{13, 3, 8}***

*=> Array **arr[] = {10, 11, 12, 13, 4, 0, 1, 2, 3, 9, 5, 6, 7, 8, 14}***

Fifth step:

*=> Second set is **{4, 9, 14}.***

=> Rotate this set by d position in cyclic order.

> => *This set becomes* ***{14, 4, 9}***
>
> => *Array* ***arr[] = {10, 11, 12, 13, 14, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9}***

Follow the steps below to solve the given problem.

- Perform **d%n** in order to keep the value of **d** within the range of the array where **d** is the number of times the array is rotated and **N** is the size of the array.
- Calculate the **GCD(N, d)** to divide the array into sets.
- Run a for loop from 0 to the value obtained from GCD.
  - Store the value of **arr[i]** in a temporary variable (the value of **i** denotes the **set number**).
  - Run a while loop to update the values according to the set.
- After exiting the while loop assign the value of **arr[j]** as the value of the temporary variable (the value of **j** denotes the last element of the **ith** set).

Below is the implementation of the above approach :

```
// C++ program to rotate an array by
// d elements
#include <bits/stdc++.h>
using namespace std;

/*Function to get gcd of a and b*/
int gcd(int a, int b)
{
    if (b == 0)
        return a;

    else        return gcd(b, a % b);
}

/*Function to left rotate arr[] of size n by d*/
void leftRotate(int arr[], int d, int n)
{
    /* To handle if d >= n */   d = d % n;
    int g_c_d = gcd(d, n);
    for (int i = 0; i < g_c_d; i++) {
```

```
        /* move i-th values of blocks */
        int temp = arr[i];
        int j = i;

        while (1) {
            int k = j + d;
            if (k >= n)
                k = k - n;

            if (k == i)
                break;

            arr[j] = arr[k];
            j = k;
        }
        arr[j] = temp;
    }
}

// Function to print an array
void printArray(int arr[], int size)
{
    for (int i = 0; i < size; i++)
        cout << arr[i] << " ";
}

/* Driver program to test above functions */
int main()
{
    int arr[] = { 1, 2, 3, 4, 5, 6, 7 };
    int n = sizeof(arr) / sizeof(arr[0]);

    // Function calling leftRotate(arr, 2, n);
    printArray(arr, n);

    return 0;
}
```

Output

```
3 4 5 6 7 1 2
```

Time complexity : O(N)

Auxiliary Space : O(1)