Complete Guide On Array Rotations – Data Structure and Algorithms Tutorial

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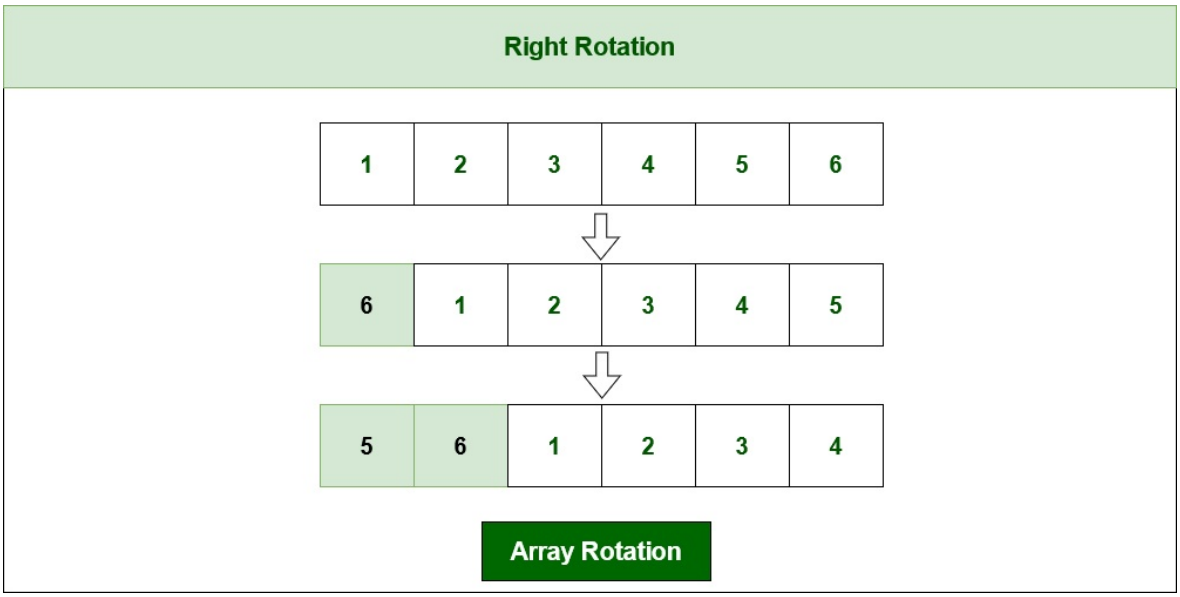
Rotations in the array is defined as the process of rearranging the elements in an array by **shifting each element** to a new position. This is mostly done by rotating the elements of the array **clockwise** or **counterclockwise.**

Types of Rotations in Array:

1. Right Rotation

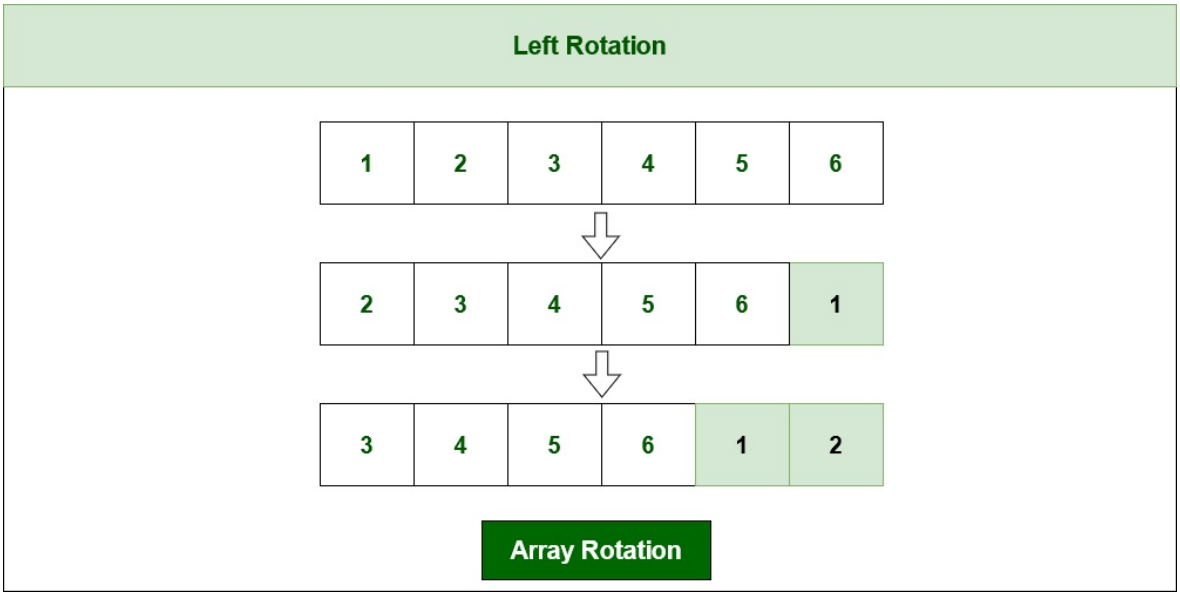
Here, The array elements are shifted towards the right.



Rotating array elements towards right by 2 places

2. Left Rotation

Here, The array elements are shifted towards the left.



Rotating array elements towards left by 2 places

How to implement rotations in an Array?

There are several ways to implement array rotations. Some of the approaches are mentioned below.

1: Rotate one by one

Here we are considering left rotation. The movements will be just the opposite for right rotation.

Intuition:

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]**, **d = 2**.

First Step:

=> Rotate to left by one position.

=> **arr[] = {2, 3, 4, 5, 6, 1}**

Second Step:

=> Rotate again to left by one position

=> **arr[] = {3, 4, 5, 6, 1, 2}**

Rotation is done 2 times.

So the array becomes **arr[] = {3, 4, 5, 6, 1, 2}**

Below are the steps to solve using the above approach:

- 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++

```cpp
// C++ code to implement the above approach
#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 array
void printArray(int arr[], int size)
{
    for (int i = 0; i < size; i++)
        cout << arr[i] << " ";
}

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

    // Function calling
```

```
    rotate(arr, d, n);
    printArray(arr, n);

    return 0;
}
```

Java

```
// Java code to implement the above approach
import java.io.*;

class GFG {

    public static 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++;
        }

        for (int i = 0; i < n; i++) {
            System.out.print(arr[i] + " ");
        }
    }

    // Driver's code
    public static void main(String[] args)
    {
        int arr[] = { 1, 2, 3, 4, 5, 6 };
        int n = arr.length;
        // Rotate 2 times
        int d = 2;

        // Function call
        rotate(arr, d, n);
    }
}
```

Python3

```
# Python program to implement the above approach

# Function to left rotate arr[] of size n by d


def rotate(arr, d, n):
    p = 1
    while(p <= d):
        last = arr[0]
        for i in range(n - 1):
            arr[i] = arr[i + 1]
        arr[n - 1] = last
        p = p + 1

# Function to print an array


def printArray(arr, size):
    for i in range(size):
        print(arr[i], end=" ")


# Driver code
arr = [1, 2, 3, 4, 5, 6]
n = len(arr)
d = 2

# Function calling
rotate(arr, d, n)
```

```
printArray(arr, n)
```

C#

```
// C# code to implement the above approach
using System;

class GFG {
    /* Function to left rotate arr[] of size n by d */
    static 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 array
    static void PrintArray(int[] arr, int size) {
        for (int i = 0; i < size; i++)
            Console.Write(arr[i] + " ");
    }

    // Driver's code
    static void Main(string[] args) {
        int[] arr = { 1, 2, 3, 4, 5, 6 };
        int n = arr.Length;
        int d = 2;

        // Function calling
        Rotate(arr, d, n);
        PrintArray(arr, n);
    }
}
```

Javascript

```
function rotateArray(arr, d, n) {
for (let i = 0; i < d; i++) {
const first = arr.shift();
arr.push(first);
}
}

// Function to print an array
function printArray(arr) {
console.log(arr.join(' '));
}

// Driver's code
const arr = [1, 2, 3, 4, 5, 6];
const n = arr.length;
const d = 2;

// Function calling
rotateArray(arr, d, n);
printArray(arr);
```

Output

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

Time Complexity: O(N * d)

Auxiliary Space: O(1)

2. Using temporary Array:

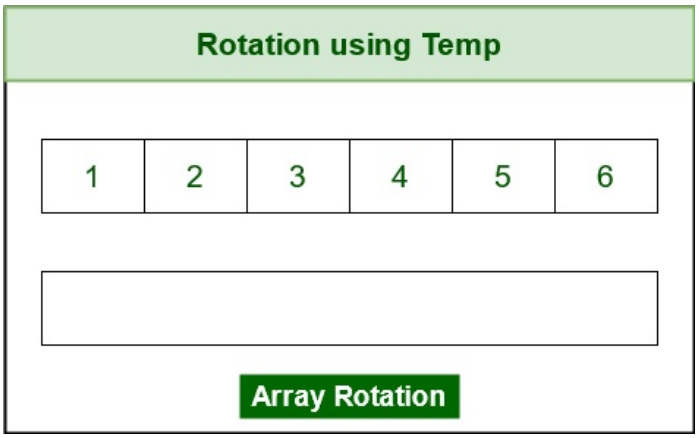
Here we are considering the right rotation. The movements will be just the opposite for left rotations.

Intuition:

In this technique, create a temporary array of size **n**, where **n** is the length of the original array. If we rotate the array by **d** positions to right, the last **d** elements will be in the front. So, copy the last **d** elements of the original array into the first **d** positions of the temporary array and copy the remaining elements in the remaining positions. Finally, copy the elements of the temporary array back into the original array starting at position 0.

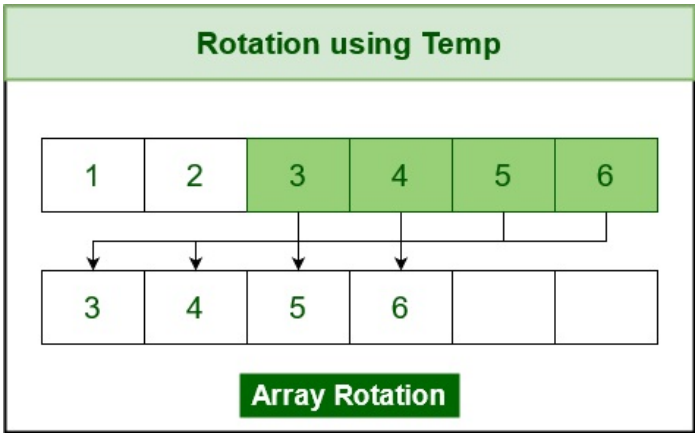
Illustration:

- Initialize an empty temp array, to store the final rotated state of the original array.



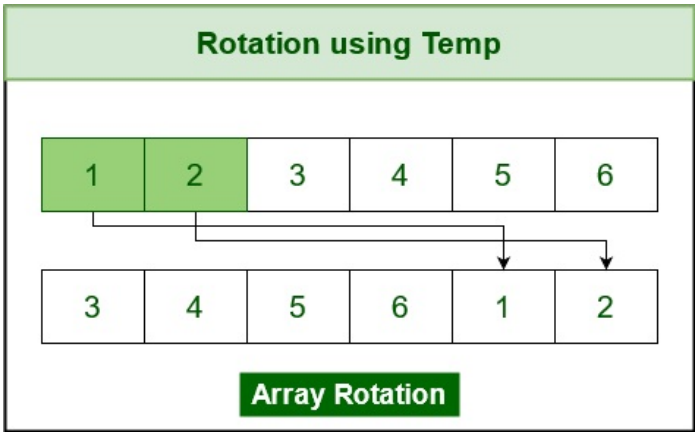
Example of array

- Copy all elements from (n-d) to the end of the original to the front of the temp array.



Copy last 'd' elements to the front in temp[]

- Now copy the rest elements from the front to the back of the temp[].



Copy the remaining elements to the end

Below are the steps to solve using the above approach:

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

Below is the implementation of the above approach

C++

```cpp
// C++ code to implement 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 j = 0;

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

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

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

    // Function calling
    rotate(arr, d, N);
    printTheArray(arr, N);

    return 0;
}
```

Java

```java
// Java code to implement the above approach
import java.io.*;
```

```
class GFG {

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

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

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

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

        // 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
    static void printTheArray(int arr[], int n)
    {
        for (int i = 0; i < n; i++) {
            System.out.print(arr[i] + " ");
        }
    }
    public static void main(String[] args)
    {
        int arr[] = { 1, 2, 3, 4, 5, 6 };
        int N = arr.length;
        int d = 2;

        // Function calling
        rotate(arr, d, N);
        printTheArray(arr, N);
    }
}
```

Python3

```
# Python code to implement the above approach
def rotate(L, d, n):
    k = L.index(d)
    new_lis = []
    new_lis = L[k+1:]+L[0:k+1]
    return new_lis


if __name__ == '__main__':
    arr = [1, 2, 3, 4, 5, 6]
    d = 2
    N = len(arr)

    # Function call
    arr = rotate(arr, d, N)
    for i in arr:
        print(i, end=" ")
```

C#

```
// C# code for the approach

using System;

class GFG {
      // Driver code
    static void Main(string[] args)
    {
          // Input array
        int[] arr = { 1, 2, 3, 4, 5, 6 };
        int N = arr.Length;
        int d = 2;

        // Storing rotated version of array
        int[] temp = new int[N];

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

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

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

        // 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
        foreach(int element in arr)
        {
            Console.Write(element + " ");
        }
    }
}
```

Javascript

```
function rotateArray(arr, d, n) {
// Storing rotated version of array
let temp = [];

// Keeping track of the current index
// of temp[]
let j = 0;

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

// Storing the first d elements of array arr[]
// into temp
for (let i = 0; i < d; i++) {
temp[j] = arr[i];
j++;
}

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

```
}
}

// Function to print elements of array
function printArray(arr) {
console.log(arr.join(' '));
}

// Driver's code
let arr = [1, 2, 3, 4, 5, 6];
let N = arr.length;
let d = 2;

// Function calling
rotateArray(arr, d, N);
printArray(arr);
```

Output

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

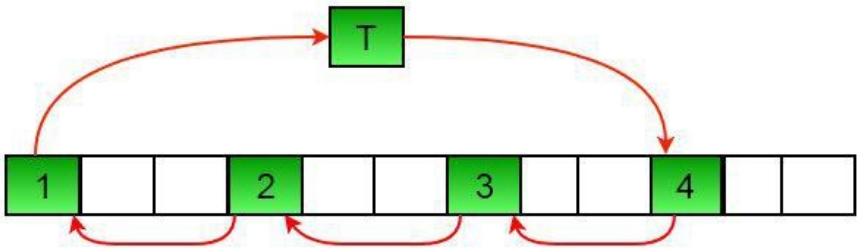
Time complexity: O(N)
Auxiliary Space: O(N)

3: Juggling Algorithm

Intuition:

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**.



Juggling Algorithm

Illustration:

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}**

Below are the steps to solve using the above approach:

- 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 **i^{th}** set).

Below is the implementation of the above approach:

C++

```
// C++ program to implement the above approach
#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's code
int main()
{
    int arr[] = { 1, 2, 3, 4, 5, 6 };
    int n = sizeof(arr) / sizeof(arr[0]);
    int d = 2;
    // Function calling
    leftRotate(arr, d, n);
    printArray(arr, n);

    return 0;
}
```

Java

```
// Java program to implement the above approach
import java.io.*;
class RotateArray {
    /*Function to left rotate arr[] of siz n by d*/
    void leftRotate(int arr[], int d, int n)
    {
        /* To handle if d >= n */
        d = d % n;
        int i, j, k, temp;
        int g_c_d = gcd(d, n);
        for (i = 0; i < g_c_d; i++) {
            /* move i-th values of blocks */
            temp = arr[i];
            j = i;
            while (true) {
                k = j + d;
                if (k >= n)
                    k = k - n;
                if (k == i)
                    break;
                arr[j] = arr[k];
                j = k;
            }
            arr[j] = temp;
        }
    }

    /*UTILITY FUNCTIONS*/

    /* function to print an array */
    void printArray(int arr[], int size)
    {
        int i;
        for (i = 0; i < size; i++)
            System.out.print(arr[i] + " ");
    }

    /*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);
    }

    // Driver's code
    public static void main(String[] args)
    {
        RotateArray rotate = new RotateArray();
        int arr[] = { 1, 2, 3, 4, 5, 6 };
        int n = 6;
        int d = 2;
        rotate.leftRotate(arr, d, n);
        rotate.printArray(arr, n);
    }
}
```

Python3

```
# Python code to implement the above approach


# Function to rotate the array left by d positions
def leftRotate(arr, d, n):
    d = d % n
    g_c_d = gcd(d, n)
    for i in range(g_c_d):

        # move i-th values of blocks
        temp = arr[i]
        j = i
        while 1:
            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
def printArray(arr, size):
    for i in range(size):
        print(arr[i], end=" ")


# Function to get gcd of a and b
def gcd(a, b):
    if b == 0:
        return a
    else:
        return gcd(b, a % b)


# Driver code
if __name__ == '__main__':
    arr = [1, 2, 3, 4, 5, 6]
    n = len(arr)
    d = 2
    leftRotate(arr, d, n)
    printArray(arr, n)
```

C#

```
using System;

namespace LeftRotation
{
  class Program
  {
    // Function to get gcd of a and b
```

```
    static 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
    static 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 (true)
        {
          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
    static void printArray(int[] arr, int size)
    {
      for (int i = 0; i < size; i++)
        Console.Write(arr[i] + " ");
    }

    // Driver's code
    static public void Main(string[] args)
    {
      int[] arr = { 1, 2, 3, 4, 5, 6 };
      int n = arr.Length;
      int d = 2;
      // Function calling
      leftRotate(arr, d, n);
      printArray(arr, n);
    }
  }
}
```

Javascript

```
function gcd(a, b) {
if (b == 0) {
return a;
} else {
return gcd(b, a % b);
}
}

// Function to left rotate arr[] of size n by d
function leftRotate(arr, d, n) {
// To handle if d >= n
d = d % n;
let g_c_d = gcd(d, n);
for (let i = 0; i < g_c_d; i++) {
// move i-th values of blocks
let temp = arr[i];
let j = i;
while (1) {
```

```
let 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
function printArray(arr) {
let str = "";
for (let i = 0; i < arr.length; i++) {
str += arr[i] + " ";
}
console.log(str);
}

// Driver's code
let arr = [1, 2, 3, 4, 5, 6];
let n = arr.length;
let d = 2;

// Function calling
leftRotate(arr, d, n);
printArray(arr);
```

Output

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

Time complexity : O(N)
Auxiliary Space : O(1)

4. The Reversal Algorithm

Intuition:

If observed closely, we can see that a group of array elements is changing its position. For example see the following array:
arr[] = {1, 2, 3, 4, 5, 6} and **d = 2**. The rotated array is **{3, 4, 5, 6, 1, 2}**
The group having the first two elements is moving to the end of the array. This is like reversing the array.
But the issue is that if we only reverse the array, it becomes { 6, 5, 4, 3, 2, 1}.
After rotation, the elements in the chunks having the first 5 elements { 6, 5, 4, 3} and the last 2 elements {2, 1} should be in the actual order as of the initial array [i.e., {3, 4, 5, 6} and {1, 2}]but here it gets reversed.
So if those blocks are reversed again we get the desired rotated array.
So the sequence of operations is:

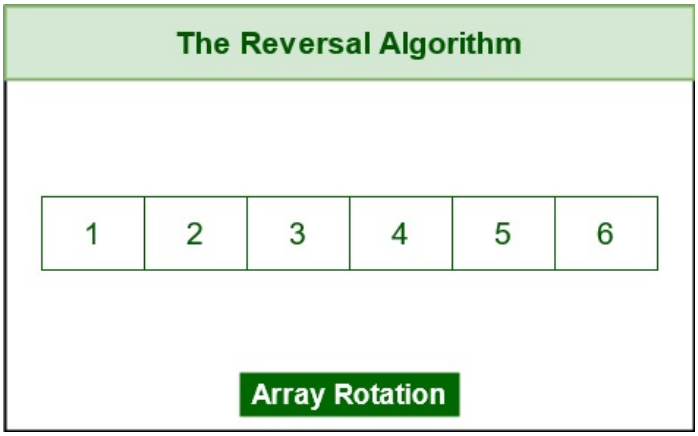
- Reverse the whole array
- Then reverse the last **'d' elements** and
- Then reverse the first **(N-d) elements**.

As we are performing reverse operations it is also similar to the following sequence:

- Reverse the first '**d**' elements
- Reverse last **(N-d)** elements
- Reverse the whole array.

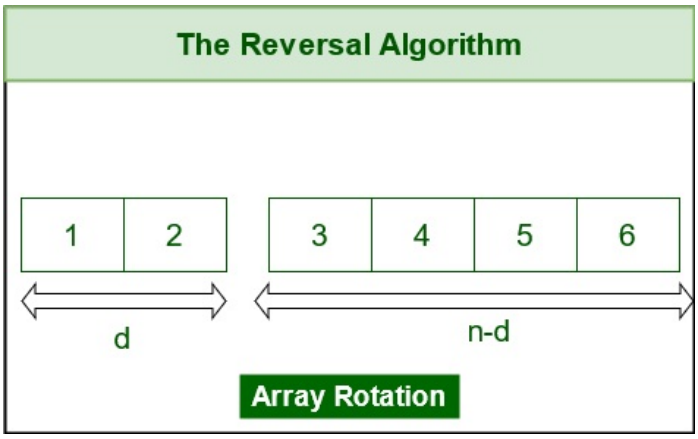
Illustration:

Take the original array as it is.



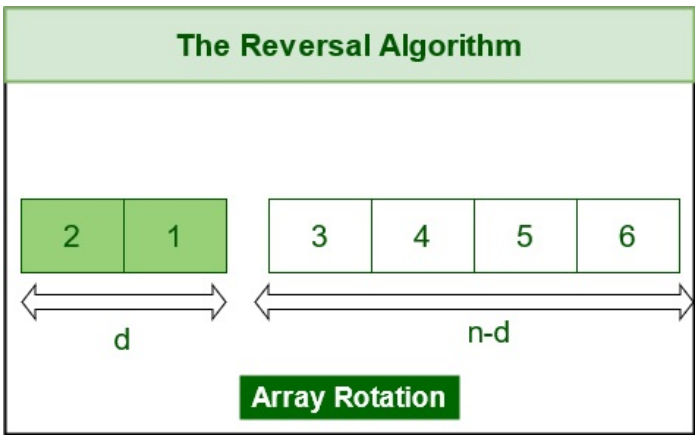
Example of Array

- Separate it out into first ‘d’ elements and ‘n-d’ elements.



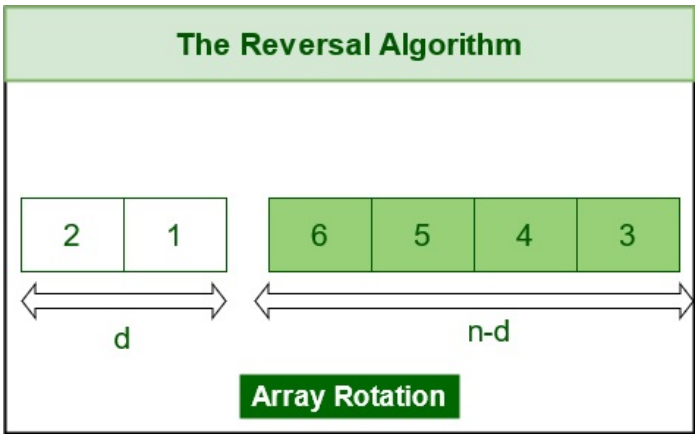
Separate array into first ‘d’ and (n-d) segment

- Reverse first ‘d’ elements.



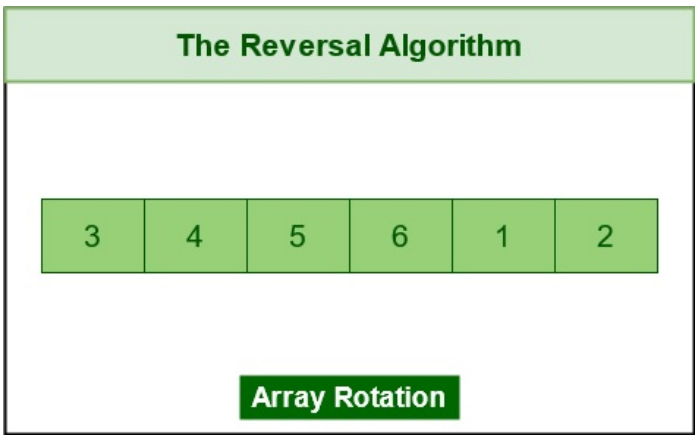
Reverse the first ‘d’ elements

- Reverse the next ‘n-d’ elements.



Reverse the next (n-d) elements

- Next, reverse the whole array. We have the final array rotated by d elements to left.



Reverse the whole array

Below is the implementation of the above approach:

C++

```
// C++ code to implement the above approach
#include <bits/stdc++.h>

using namespace std;

// Function to rotate an array by k elements to the left
void rotateArray(vector<int>& arr, int d)
{
    // Find the size of the array
    int n = arr.size();

    // Mod k with the size of the array
    // To handle the case where k is greater than the size
    // of the array
    d %= n;

    // Reverse the first k elements
    reverse(arr.begin(), arr.begin() + d);

    // Reverse the remaining n-k elements
    reverse(arr.begin() + d, arr.end());

    // Reverse the entire array
    reverse(arr.begin(), arr.end());
}

int main()
{
    // Initialize the array
    vector<int> arr = { 1, 2, 3, 4, 5, 6 };

    // Number of elements to rotate to the right
    int d = 2;
```

```
    // Call the rotateArray function to rotate the array
    rotateArray(arr, d);

    // Print the rotated array
    for (int i : arr) {
        cout << i << " ";
    }

    // Return 0 to indicate successful termination of the
    // program
    return 0;
}
```

Java

```
// Java program to implement the above approach
import java.io.*;

class LeftRotate {
    /* Function to left rotate arr[] of size n by d */
    static void leftRotate(int arr[], int d)
    {

        if (d == 0)
            return;

        int n = arr.length;
        // in case the rotating factor is
        // greater than array length
        d = d % n;
        reverseArray(arr, 0, d - 1);
        reverseArray(arr, d, n - 1);
        reverseArray(arr, 0, n - 1);
    }

    /*Function to reverse arr[] from index start to end*/
    static void reverseArray(int arr[], int start, int end)
    {
        int temp;
        while (start < end) {
            temp = arr[start];
            arr[start] = arr[end];
            arr[end] = temp;
            start++;
            end--;
        }
    }

    /*UTILITY FUNCTIONS*/
    /* function to print an array */
    static void printArray(int arr[])
    {
        for (int i = 0; i < arr.length; i++)
            System.out.print(arr[i] + " ");
    }

    /* Driver program to test above functions */
    public static void main(String[] args)
    {
        int arr[] = { 1, 2, 3, 4, 5, 6 };
        int n = arr.length;
        int d = 2;

        leftRotate(arr, d); // Rotate array by d
        printArray(arr);
    }
}
```

Python3

```
# Python code to implement the above approach


# Function to reverse start to end of array
```

```python
def reverseArray(arr, start, end):
    while (start < end):
        temp = arr[start]
        arr[start] = arr[end]
        arr[end] = temp
        start += 1
        end = end-1


# Function to left rotate arr[] of size n by d
def leftRotate(arr, d):

    if d == 0:
        return
    n = len(arr)
    # in case the rotating factor is
    # greater than array length
    d = d % n
    reverseArray(arr, 0, d-1)
    reverseArray(arr, d, n-1)
    reverseArray(arr, 0, n-1)


# Function to print an array
def printArray(arr):
    for i in range(0, len(arr)):
        print(arr[i], end=' ')


# Driver code
if __name__ == '__main__':
    arr = [1, 2, 3, 4, 5, 6]
    n = len(arr)
    d = 2
    leftRotate(arr, d)
    printArray(arr)
```

C#

```csharp
// C# program to implement the above approach
using System;

class LeftRotate {
    /* Function to left rotate arr[] of size n by d */
    static void leftRotate(int[] arr, int d)
    {

        if (d == 0)
            return;

        int n = arr.Length;
        // in case the rotating factor is
        // greater than array length
        d = d % n;
        reverseArray(arr, 0, d - 1);
        reverseArray(arr, d, n - 1);
        reverseArray(arr, 0, n - 1);
    }

    /*Function to reverse arr[] from index start to end*/
    static void reverseArray(int[] arr, int start, int end)
    {
        int temp;
        while (start < end) {
            temp = arr[start];
            arr[start] = arr[end];
            arr[end] = temp;
            start++;
            end--;
        }
    }

    /*UTILITY FUNCTIONS*/
    /* function to print an array */
    static void printArray(int[] arr)
    {
```

```
        for (int i = 0; i < arr.Length; i++)
            Console.Write(arr[i] + " ");
    }

    /* Driver program to test above functions */
    public static void Main()
    {
        int[] arr = { 1, 2, 3, 4, 5, 6 };
        int n = arr.Length;
        int d = 2;

        leftRotate(arr, d); // Rotate array by d
        printArray(arr);
    }
}


// This code is contributed by Vaibhav Nandan
```

Javascript

```
/*Function to reverse arr[] from index start to end*/
     function reverseArray(arr, s, e) {
       while (s < e) {
         var temp = arr[s];
         arr[s] = arr[e];
         arr[e] = temp;
         s++;
         e--;
       }
     }

     /* Function to left rotate arr[] of size n by d */
     function leftRotate(arr, d, n) {
       if (d == 0) return;
       // in case the rotating factor is
       // greater than array length
       d = d % n;

       reverseArray(arr, 0, d - 1);
       reverseArray(arr, d, n - 1);
       reverseArray(arr, 0, n - 1);
     }

     // Function to print an array
     function printArray(arr, size)
     {
       console.log(arr.join(' '));
     }

     /* Driver program to test above functions */

     var arr = [1, 2, 3, 4, 5, 6, 7];
     var n = arr.length;
     var d = 2;

     // Function calling
     leftRotate(arr, d, n);
     printArray(arr, n);
```

Output

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

Time Complexity: O(N)

Auxiliary Space: O(1)

Applications of Array Rotation:

They are useful in a variety of applications, broadly speaking, we have:-

- **Searching in a sorted and rotated array**: If an array is sorted in ascending order and then rotated by some number of positions, it can still be searched efficiently using binary search.
- **Game development**: In game development, array rotation is useful for implementing various game mechanics, such as

rotating a game board or changing the orientation of game objects.
- **Audio and video processing**: In audio and video processing, array rotation can be used to apply effects such as pitch shifting, time stretching, and stereo panning.
- **Text editing**: In text editing software, array rotation can be used to implement text selection and deletion operations, as well as undo and redo functionality.

Some FAQs regarding Array Rotation:

1. Can Array Rotation be used to implement any data structures?

It can be used to implement several data structures such as **circular buffers** and **circular queues**. In a circular buffer, array rotation is used to move the read and write pointers around the buffer, while in a circular queue, array rotation is used to remove the oldest element and add the newest element.

2. Is Array Rotation in place or takes extra space?

Array rotation can be performed in place, which means that the original array is modified directly without using any additional memory. This can be useful in situations where memory usage is a concern.

3. Is there any relation between modular-arithmetic and array rotation?

Array rotation is closely related to the concept of modular arithmetic, which is used to perform arithmetic operations on integers that are defined modulo a given number. In the case of array rotation, the modulo operation is used to calculate the new position of each element in the array after rotation.

Advantages of Rotations in an Array:

Rotating an array can have several advantages depending on the context in which it is used. Here are some potential benefits of rotating an array:

- **Improved performance**: In some cases, rotating an array can make it more efficient to perform certain operations. For example, if you need to perform many searches or lookups on an array, rotating it may allow you to use faster algorithms or data structures.
- **More flexible data representation**: Rotating an array can allow you to represent data in different ways, which can make it easier to work with or analyze. For example, you might rotate a matrix to represent it as a vector or to change the orientation of the data.
- **Simplified computations**: Rotating an array can make it easier to perform certain computations. For example, if you are working with a matrix and need to multiply it by a vector, rotating the matrix can simplify the computation by allowing you to use the dot product instead of matrix multiplication.

Some Popular Interview Problems on Array Rotation

- Program for array left rotation by d positions
- Find the Rotation Count in Rotated Sorted array

- Maximum sum of i*arr[i] among all rotations of a given array
- Find the Minimum element in a Sorted and Rotated Array
- Quickly find multiple left rotations of an array

Some other Important Problems/Articles on the same

- Rotate Array by N elements
- Reversal algorithm for Array rotation
- Program to cyclically rotate an array by one
- Print array after it is right rotated K times
- Print left rotation of array in O(n) time and O(1) space

Conclusion:

In some cases, the benefits of rotating an array may outweigh the drawbacks, while in other cases it may not be necessary or may even be detrimental. It's important to carefully consider the potential tradeoffs before deciding to rotate an array.

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Find maximum value of Sum(i*arr[i]) with only rotations on given array allowed

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