Maximum difference between two elements such that larger element appears after the smaller number

Given an array arr[] of integers, find out the difference between any two elements **such that larger element appears after the smaller number** in arr[].

Examples: If array is [2, 3, 10, 6, 4, 8, 1] then returned value should be 8 (Diff between 10 and 2). If array is [7, 9, 5, 6, 3, 2] then returned value should be 2 (Diff between 7 and 9)

Method 1 (Simple)

Use two loops. In the outer loop, pick elements one by one and in the inner loop calculate the difference of the picked element with every other element in the array and compare the difference with the maximum difference calculated so far.

```
#include<stdio.h>

/* The function assumes that there are at least two
   elements in array.
   The function returns a negative value if the array is
   sorted in decreasing order.
   Returns 0 if elements are equal */
int maxDiff(int arr[], int arr_size)
{
  int max_diff = arr[1] - arr[0];
  int i, j;
  for(i = 0; i < arr_size; i++)
  {
    for(j = i+1; j < arr_size; j++)
    {
      if(arr[j] - arr[i] > max_diff)
         max_diff = arr[j] - arr[i];
    }
  }
  return max_diff;
}

/* Driver program to test above function */
int main()
{
  int arr[] = {1, 2, 90, 10, 110};
  printf("Maximum difference is %d",  maxDiff(arr, 5));
  getchar();
```

```
  return 0;
}
```

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Time Complexity: O(n^2)

Auxiliary Space: O(1)

Method 2 (Tricky and Efficient)

In this method, instead of taking difference of the picked element with every other element, we take the difference with the minimum element found so far. So we need to keep track of 2 things:

1) Maximum difference found so far (max_diff).

2) Minimum number visited so far (min_element).

```
#include<stdio.h>

/* The function assumes that there are at least two
   elements in array.
   The function returns a negative value if the array is
   sorted in decreasing order.
   Returns 0 if elements are equal  */
int maxDiff(int arr[], int arr_size)
{
  int max_diff = arr[1] - arr[0];
  int min_element = arr[0];
  int i;
  for(i = 1; i < arr_size; i++)
  {
    if (arr[i] - min_element > max_diff)
      max_diff = arr[i] - min_element;
    if (arr[i] < min_element)
         min_element = arr[i];
  }
  return max_diff;
}

/* Driver program to test above function */
int main()
{
  int arr[] = {1, 2, 6, 80, 100};
  int size = sizeof(arr)/sizeof(arr[0]);
  printf("Maximum difference is %d",  maxDiff(arr, size));
  getchar();
  return 0;
}
```

Run on IDE

Time Complexity: O(n)

Auxiliary Space: O(1)

Like min element, we can also keep track of max element from right side. See below code suggested by Katamaran

```
int maxDiff(int arr[], int n)
{
    int maxDiff = -1; // Initialize Result
```

```
    int maxRight = arr[n-1]; // Initialize max element from right side

    for (int i = n-2; i >= 0; i--)
    {
        if (arr[i] > maxRight)
            maxRight = arr[i];
        else
        {
            int diff = maxRight - arr[i];
            if (diff > maxDiff)
            {
                maxDiff = diff;
            }
        }
    }
    return maxDiff;
}
```

Run on IDE

Method 3 (Another Tricky Solution)

First find the difference between the adjacent elements of the array and store all differences in an auxiliary array diff[] of size n-1. Now this problems turns into finding the maximum sum subarray of this difference array. Thanks to Shubham Mittal for suggesting this solution.

```
#include<stdio.h>

int maxDiff(int arr[], int n)
{
    // Create a diff array of size n-1. The array will hold
    //  the difference of adjacent elements
    int diff[n-1];
    for (int i=0; i < n-1; i++)
        diff[i] = arr[i+1] - arr[i];

    // Now find the maximum sum subarray in diff array
    int max_diff = diff[0];
    for (int i=1; i<n-1; i++)
    {
        if (diff[i-1] > 0)
            diff[i] += diff[i-1];
        if (max_diff < diff[i])
            max_diff = diff[i];
    }
    return max_diff;
}

/* Driver program to test above function */
int main()
{
    int arr[] = {80, 2, 6, 3, 100};
    int size = sizeof(arr)/sizeof(arr[0]);
    printf("Maximum difference is %d",  maxDiff(arr, size));
    return 0;
}
```

Run on IDE

Output:

98

This method is also O(n) time complexity solution, but it requires O(n) extra space

Time Complexity: O(n)
Auxiliary Space: O(n)

We can modify the above method to work in O(1) extra space. Instead of creating an auxiliary array, we can calculate diff and max sum in same loop. Following is the space optimized version.

```
int maxDiff (int arr[], int n)
{
    // Initialize diff, current sum and max sum
    int diff = arr[1]-arr[0];
    int curr_sum = diff;
    int max_sum = curr_sum;

    for(int i=1; i<n-1; i++)
    {
        // Calculate current diff
        diff = arr[i+1]-arr[i];

        // Calculate current sum
        if (curr_sum > 0)
           curr_sum += diff;
        else
           curr_sum = diff;

        // Update max sum, if needed
        if (curr_sum > max_sum)
           max_sum = curr_sum;
    }

    return max_sum;
}
```

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Time Complexity: O(n)
Auxiliary Space: O(1)

Please write comments if you find any bug in above codes/algorithms, or find other ways to solve the same problem

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