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

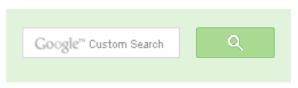
Given an array arr[] of integers, find out the difference between any two elements such that larger element appears after the smaller number in arr[].

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, \bar{j};
  for(i = 0; i < arr size; i++)</pre>
    for(j = i+1; j < arr size; j++)</pre>
      if(arr[j] - arr[i] > max_diff)
         max diff = arr[j] - arr[i];
```





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```
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;
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++)</pre>
    if(arr[i] - min element > max diff)
      max diff = arr[i] - min element;
    if(arr[i] < min element)</pre>
         min element = arr[i];
  return max diff;
/* Driver program to test above function */
```



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```
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;
}
Time Complexity: O(n)
Auxiliary Space: O(1)
```

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])</pre>
            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;
```

705



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;
```

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

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