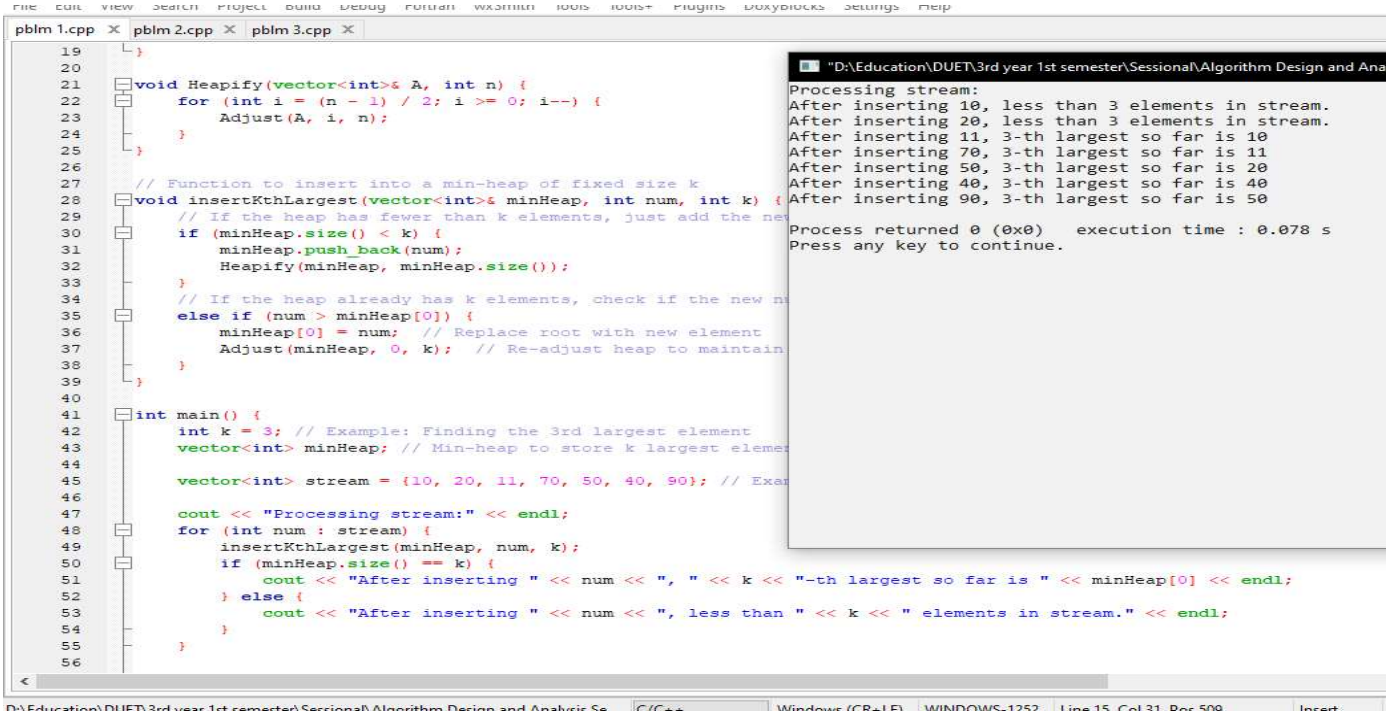
/* 1) Given an infinite stream of integers, return the element representing the k th largest element in the stream. (Hint: Use Min-heap) */

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

void Adjust(vector<int>& A, int i, int n)
{
    int j = 2 * i + 1;  // Left child index , Adjusted for 0-based index
    int item = A[i];  // Store the current node value

    while (j < n)
    {
        // If the right child exists and is greater than the left child
        if ((j + 1 < n) && (A[j] > A[j + 1])) // Compare with right child
            j = j + 1;
        if (item <= A[j])
            break;
        A[(j - 1) / 2] = A[j];
        j = 2 * j + 1;
    }
    A[(j - 1) / 2] = item;
}

void Heapify(vector<int>& A, int n)
{
    for (int i = (n - 1) / 2; i >= 0; i--)
        Adjust(A, i, n);
}

// Function to insert into a min-heap of fixed size k
void insertKthLargest(vector<int>& minHeap, int num, int k)
{
    // If the heap has fewer than k elements, just add the new element
    if (minHeap.size() < k)
    {
        minHeap.push_back(num);
        Heapify(minHeap, minHeap.size());
    }
    // If the heap already has k elements, check if the new number should replace the root
    else if (num > minHeap[0])
    {
        minHeap[0] = num;  // Replace root with new element
        Adjust(minHeap, 0, k);  // Re-adjust heap to maintain min-heap property
```

```
    }
}

int main()
{
    int k = 3; // Example: Finding the 3rd largest element
    vector<int> minHeap; // Min-heap to store k largest elements

    vector<int> stream = {10, 20, 11, 70, 50, 40, 90}; // Example stream

    cout << "Processing stream:" << endl;
    for (int num : stream) {
        insertKthLargest(minHeap, num, k);
        if (minHeap.size() == k)
            cout << "After inserting " << num << ", " << k << "-th largest so far is " <<
minHeap[0] << endl;
        else
            cout << "After inserting " << num << ", less than " << k << " elements in
stream." << endl;
    }

    return 0;
}
```

Output:

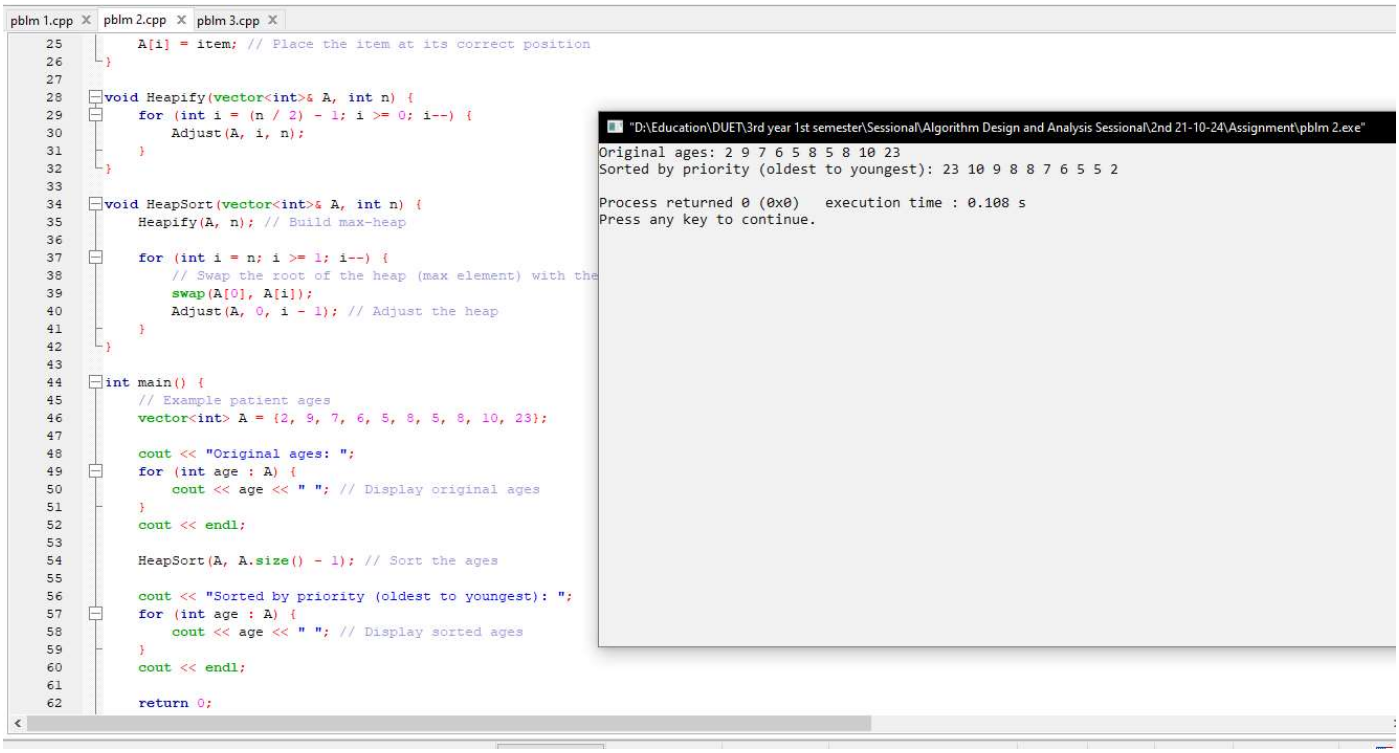


/* 2) Suppose a hospital's emergency room is filled with individuals of various ages. Sort the patients efficiently so that the oldest patients receive care first. (Hint: Use Max-heap) */

```
// Max heap
#include <bits/stdc++.h>
#include <chrono>

using namespace std;

void Adjust(vector<int>& A, int i, int n)
{
    int j = 2 * i ; // Left child index , Adjusted for 0-based index
    int item = A[i]; // Store the current node value

    while (j <= n)
    {
        // If the right child exists and is greater than the left child
        if (j < n && A[j] > A[j + 1])
            j++; // Move to right child
        // If the item is greater than or equal to the largest child, we break
        if (item <= A[j])
            break;

        // Move the child up to the parent
        A[j/2] = A[j];
        // Move down to the child
        j = 2 * j; // Update the child index
    }
    A[j/2] = item; // Place the item at its correct position
}

void Heapify(vector<int>& A, int n)
{
    for (int i = (n / 2) ; i >= 0; i--)
        Adjust(A, i, n);
}

void HeapSort(vector<int>& A, int n)
{
    Heapify(A, n); // Build max-heap

    for (int i = n; i >= 1; i--)
    {
        // Swap the root of the heap (max element) with the last element
        int t = A[i];
        A[i] = A[0];
        A[0] = t;
        Adjust(A, 0, i - 1); // Adjust the heap
    }
}
```

```
int main()
{
    // Example patient ages
    vector<int> A = {2, 9, 7, 6, 5, 8, 5, 8, 10, 23};

    cout << "Original ages: ";
    for (int age : A)
        cout << age << " "; // Display original ages
    cout << endl;

    HeapSort(A, A.size() - 1); // Sort the ages

    cout << "Sorted by priority (oldest to youngest): ";
    for (int age : A)
        cout << age << " "; // Display sorted ages
    cout << endl;

    return 0;
}
```

Output:



/* 3) You are given k sorted arrays, each containing n integers. Write a function that efficiently merges these k sorted arrays into a single sorted array. (Hint: Use Min-heap) */

```cpp
// Min-heap implementation to merge k sorted arrays
#include <bits/stdc++.h>
#include <chrono>

using namespace std;

// Adjust the heap to maintain the min-heap property
void Adjust(vector<int>& A, int i, int n)
{
    int j = 2 * i; // Start with the left child
    int item = A[i];

    while (j <= n)
    {
        if (j <= n && A[j] > A[j + 1]) // Compare with right child
            j = j + 1;
        if (item <= A[j])
            break;
        A[j/2] = A[j];
        // Move down to the child
        j = 2 * j; // Update the child index
    }
    A[j/2] = item; // Place the item at its correct position
}

// Function to heapify the array
void Heapify(vector<int>& A, int n)
{
    for (int i = (n / 2) ; i >= 0; i--)
        Adjust(A, i, n);
}

// Function to merge k sorted arrays
vector<int> mergeKSortedArrays(vector<vector<int>>& arrays)
{
    vector<int> heap;

    // Push the first element of each array into the heap
    for (const auto& arr : arrays)
    {
        for (int num : arr)
            heap.push_back(num);
    }

    int n = heap.size();
    Heapify(heap, n - 1); // Create a min-heap from the elements

    vector<int> result;
```

```
    // Extract elements from the min-heap
    for (int i = n - 1; i >= 0; i--)
    {
        result.push_back(heap[0]); // Get the minimum element
        heap[0] = heap[i]; // Move the last element to the root
        Adjust(heap, 0, i - 1); // Adjust the heap
    }
    return result; // Return the merged array
}

int main()
{
    vector<vector<int>> arrays = {
        {1, 4, 17, 10},
        {2, 5, 8},
        {7 ,3, 6, 9 }
    };

    vector<int> mergedArray = mergeKSortedArrays(arrays);

    cout << "Merged sorted array: ";
    for (int num : mergedArray)
        cout << num << " ";
    cout << endl;

    return 0;
}
```

Output: