/* 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() {
```

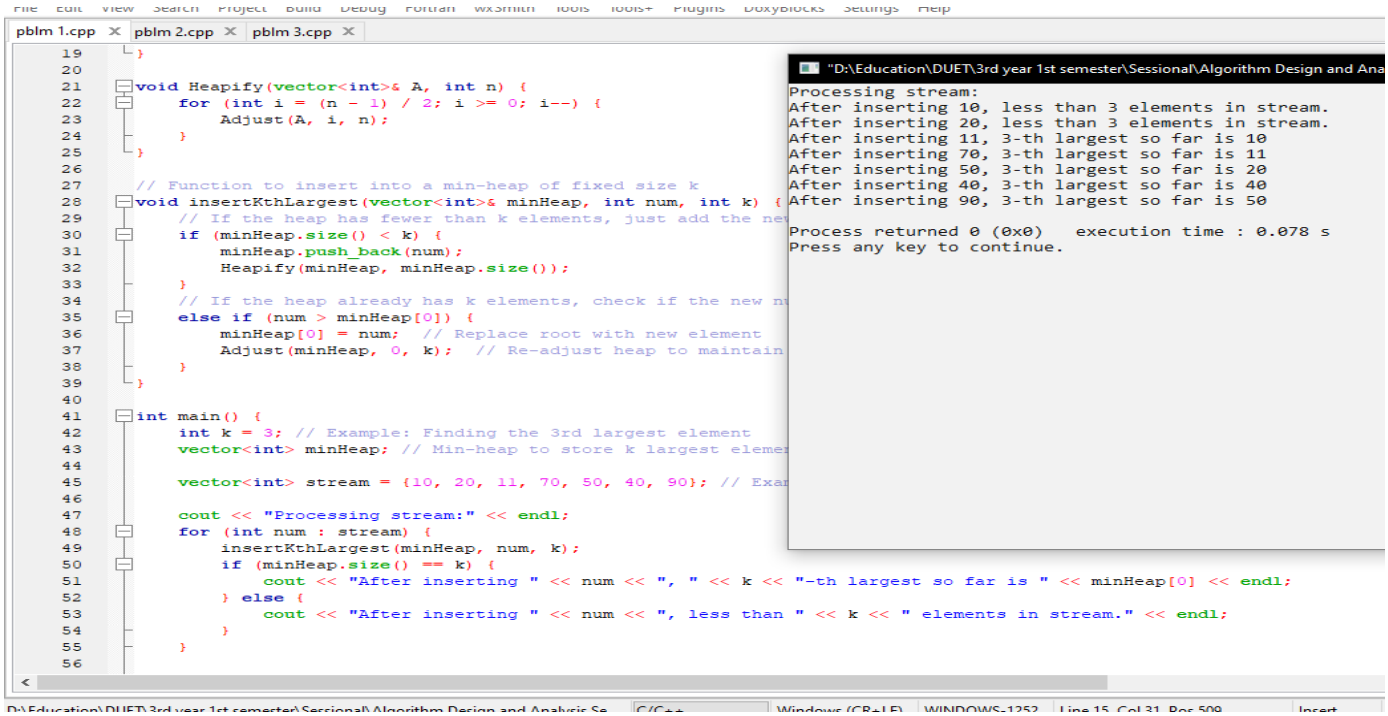
```
    int k = 3; // Example: Finding the 3rd largest element
    vector<int> minHeap; // Min-heap to store k largest elements

    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>
```

```cpp
#include <chrono>

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 < 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[i] = A[j];
        i = j; // Move down to the child
        j = 2 * i + 1; // Update the child index
    }
    A[i] = item; // Place the item at its correct position
}

void Heapify(vector<int>& A, int n) {
    for (int i = (n / 2) - 1; 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
        swap(A[0], A[i]);
        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
```

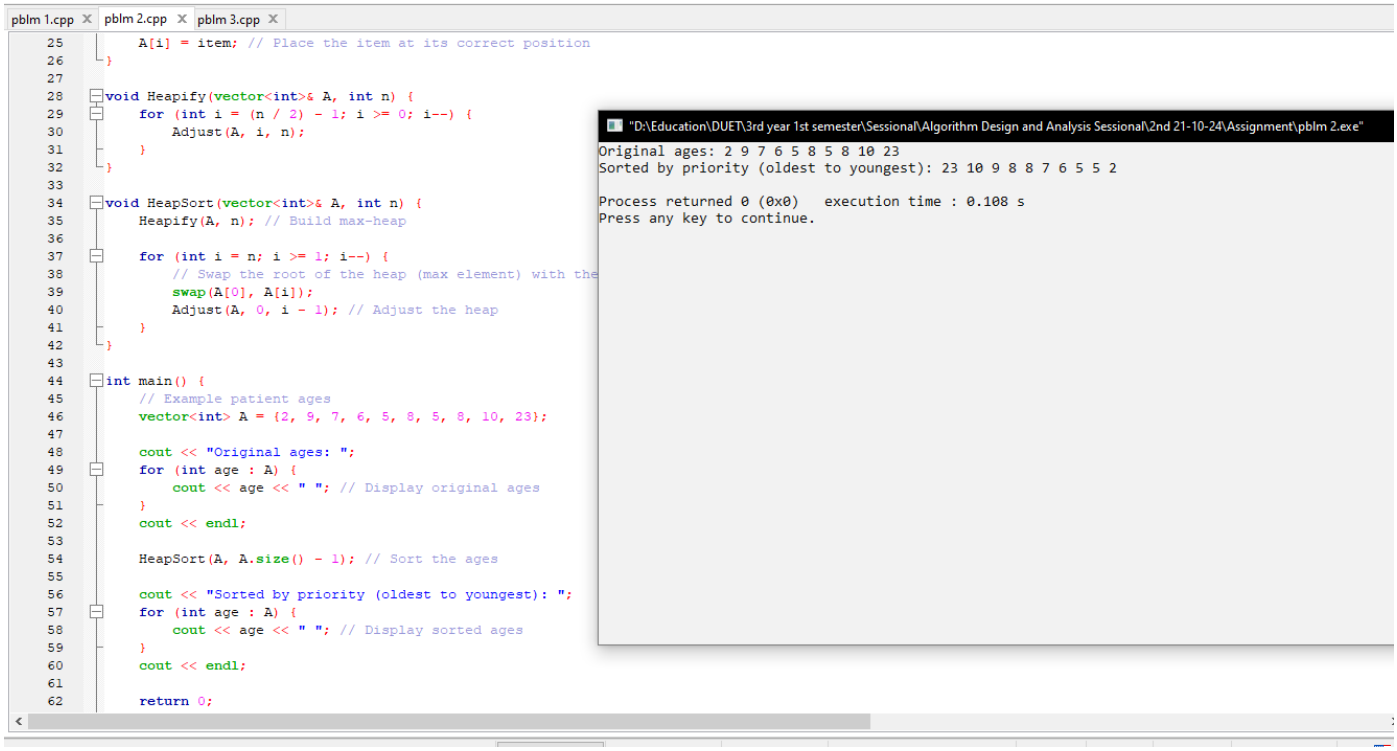
```
    }
    cout << endl;

    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) */

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

using namespace std;
```

```cpp
// Adjust the heap to maintain the min-heap property
void Adjust(vector<int>& A, int i, int n) {
    int j = 2 * i + 1; // Start with the left child
    int item = A[i];

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

// Function to heapify the array
void Heapify(vector<int>& A, int n) {
    for (int i = (n / 2) - 1; 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& array : arrays) {
        for (int num : array) {
            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:

```
pblm 1.cpp | pblm 2.cpp | pblm 3.cpp
 7  // Adjust the heap to maintain the min-heap property
 8  void Adjust(vector<int>& A, int i, int n) {
 9      int j = 2 * i + 1; // Start with the left child
10      int item = A[i];
11
12      while (j <= n) {
13          if (j + 1 <= n && A[j] > A[j + 1]) // Compare with ri
14              j = j + 1;
15          if (item <= A[j])
16              break;
17          A[i] = A[j]; // Move the smaller child up
18          i = j; // Move down the tree
19          j = 2 * i + 1; // Update the child index
20      }
21      A[i] = item; // Place the item in its correct position
22  }
23
24  // Function to heapify the array
25  void Heapify(vector<int>& A, int n) {
26      for (int i = (n / 2) - 1; i >= 0; i--) {
27          Adjust(A, i, n);
28      }
29  }
30
31  // Function to merge k sorted arrays
32  vector<int> mergeKSortedArrays(vector<vector<int>>& arrays) {
33      vector<int> heap;
34
35      // Push the first element of each array into the heap
36      for (const auto& array : arrays) {
37          for (int num : array) {
38              heap.push_back(num);
39          }
40      }
41
42      int n = heap.size();
43      Heapify(heap, n - 1); // Create a min-heap from the elements
44
```

```
"D:\Education\DUET\3rd year 1st semester\Sessional\Algorithm Design and Analysis Sessional\2nd 21-10-24\Assignment\pblm 3.exe
Merged sorted array: 1 2 3 4 5 6 7 8 9 10 17

Process returned 0 (0x0)   execution time : 0.087 s
Press any key to continue.
```