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Day – 12Heaps

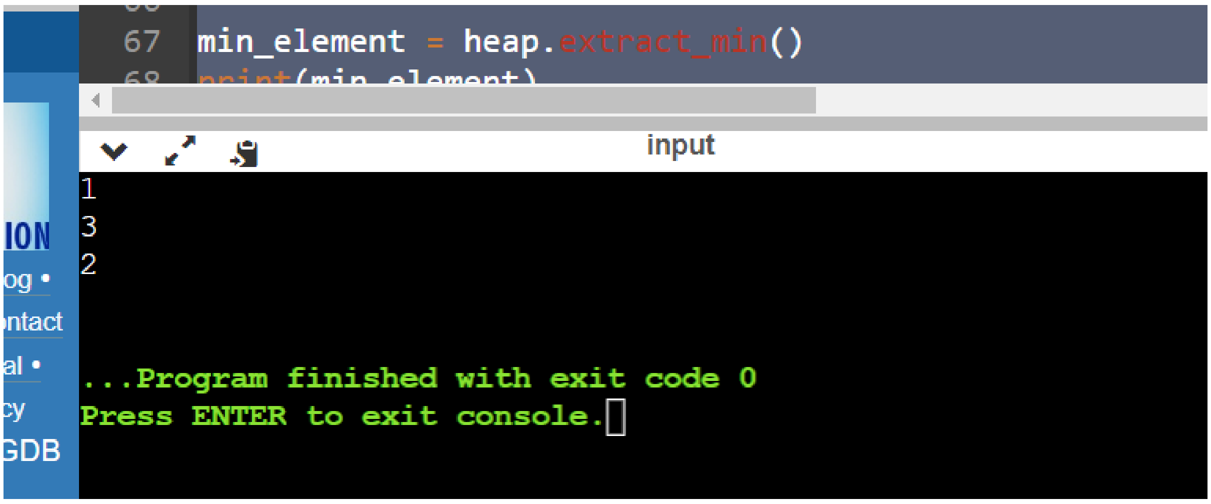
Problem Statement: Min Heap & Max Heap

1. **Min Heap**

```
class MinHeap:
  def __init__(self):
    self.heap = []

  def parent(self, i):
    return (i - 1) // 2

  def left_child(self, i):
    return 2 * i + 1

  def right_child(self, i):
    return 2 * i + 2

  def swap(self, i, j):
    self.heap[i], self.heap[j] = self.heap[j], self.heap[i]

  def insert(self, item):
    self.heap.append(item)
    self.heapify_up(len(self.heap) - 1)

  def extract_min(self):
    if len(self.heap) == 0:
      return None

    min_item = self.heap[0]
    self.swap(0, len(self.heap) - 1)
    self.heap.pop()
```

```
        self.heapify_down(0)
        return min_item

    def heapify_up(self, i):
        while i > 0 and self.heap[i] < self.heap[self.parent(i)]:
            self.swap(i, self.parent(i))
            i = self.parent(i)

    def heapify_down(self, i):
        smallest = i
        left = self.left_child(i)
        right = self.right_child(i)

        if left < len(self.heap) and self.heap[left] < self.heap[smallest]:
            smallest = left

        if right < len(self.heap) and self.heap[right] < self.heap[smallest]:
            smallest = right

        if smallest != i:
            self.swap(i, smallest)
            self.heapify_down(smallest)

heap = MinHeap()

heap.insert(5)
heap.insert(3)
heap.insert(8)
heap.insert(1)
heap.insert(10)
```

```
min_element = heap.extract_min()
print(min_element)

min_element = heap.extract_min()
print(min_element)

heap.insert(2)

min_element = heap.extract_min()
print(min_element)
```



```
min_element = heap.extract_min()
print(min_element)
```

```
1
3
2


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```
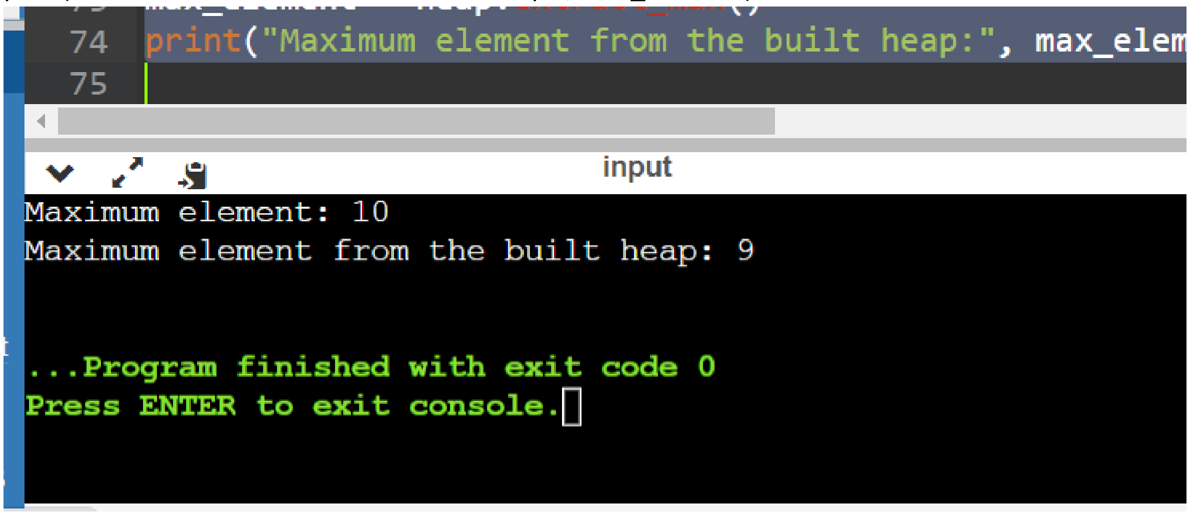

2. Max Heap

```
class MaxHeap:
  def __init__(self):
    self.heap = []

  def parent(self, i):
    return (i - 1) // 2

  def left_child(self, i):
    return 2 * i + 1

  def right_child(self, i):
    return 2 * i + 2

  def swap(self, i, j):
        self.heap[i], self.heap[j] = self.heap[j], self.heap[i]

    def insert(self, value):
        self.heap.append(value)
        current = len(self.heap) - 1
        while (
            current > 0
            and self.heap[current] > self.heap[self.parent(current)]
        ):
            self.swap(current, self.parent(current))
            current = self.parent(current)

    def heapify(self, n, i):
        largest = i
        left = self.left_child(i)
        right = self.right_child(i)

        if left < n and self.heap[left] > self.heap[largest]:
            largest = left

        if right < n and self.heap[right] > self.heap[largest]:
            largest = right

        if largest != i:
            self.swap(i, largest)
            self.heapify(n, largest)

    def build_heap(self, arr):
        n = len(arr)
        self.heap = arr
        for i in range(n // 2 - 1, -1, -1):
            self.heapify(n, i)

    def extract_max(self):
        if len(self.heap) == 0:
            return None

        max_value = self.heap[0]
        self.heap[0] = self.heap[-1]
        self.heap.pop()
        self.heapify(len(self.heap), 0)
        return max_value

# Create a new max heap
heap = MaxHeap()

heap.insert(5)
heap.insert(10)
heap.insert(3)
heap.insert(8)
heap.insert(1)

max_element = heap.extract_max()
print("Maximum element:", max_element)

arr = [7, 2, 9, 4, 6]
heap.build_heap(arr)

max_element = heap.extract_max()
print("Maximum element from the built heap:", max_element)
```



```
print("Maximum element from the built heap:", max_elem
```

```
Maximum element: 10
Maximum element from the built heap: 9


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```
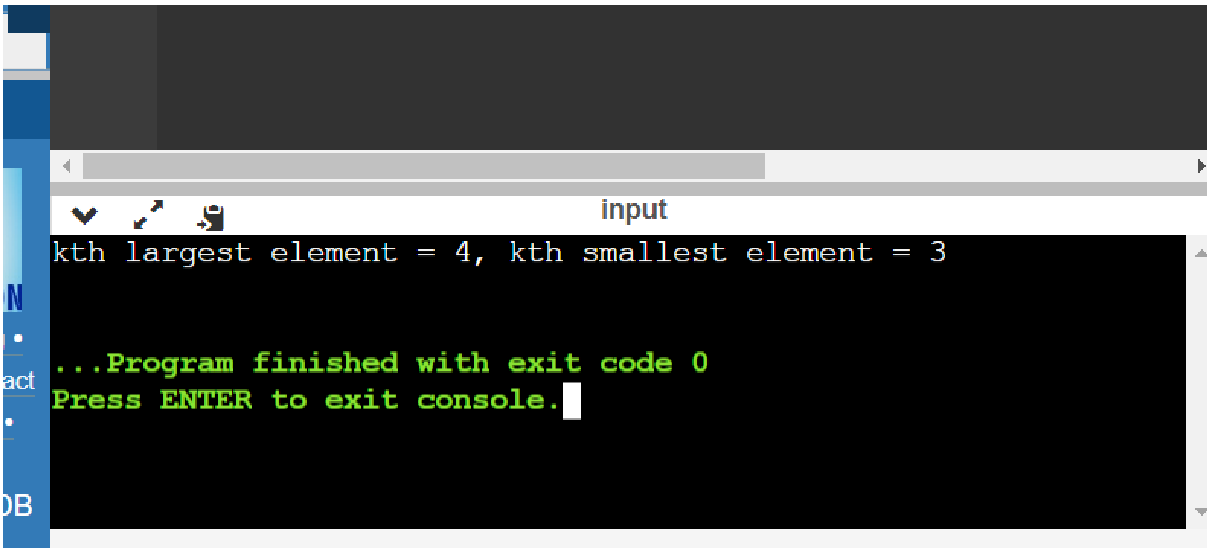

Problem Statement: Given an unsorted array, print Kth Largest and Smallest Element from an unsorted array.

```
def find_kth_largest_smallest(array, k):

array.sort()

kth_smallest = array[k - 1]

kth_largest = array[len(array) - k]

print(f"kth largest element = {kth_largest}, kth smallest element = {kth_smallest}")


array = [1, 2, 6, 4, 5, 3]

k = 3

find_kth_largest_smallest(array, k)
```



```
kth largest element = 4, kth smallest element = 3


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```

Problem Statement: Given two equally sized 1-D arrays **A, B** containing **N** integers each.

A **sum combination** is made by adding one element from array **A** and another element of array **B**.

Return the **maximum C valid sum combinations** from all the possible sum combinations.

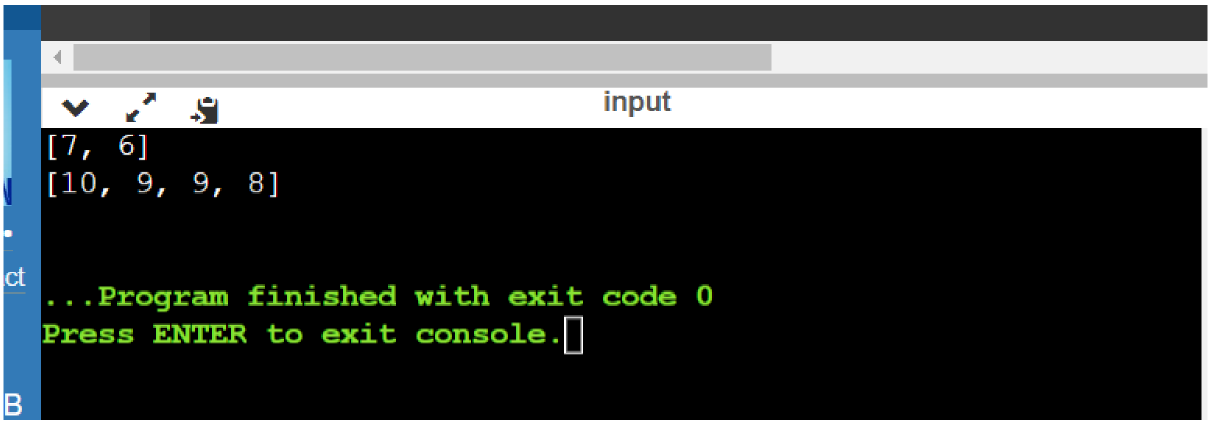
```
def find_max_sum_combinations(A, B, C):
    combinations = []
    for num_a in A:
        for num_b in B:
            combinations.append(num_a + num_b)
    combinations.sort(reverse=True)
    return combinations[:C]


A1 = [3, 2]
B1 = [1, 4]
C1 = 2
print(find_max_sum_combinations(A1, B1, C1))


A2 = [1, 4, 2, 3]
B2 = [2, 5, 1, 6]
```

```
C2 = 4

print(find_max_sum_combinations(A2, B2, C2))
```



```
[7, 6]
[10, 9, 9, 8]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```
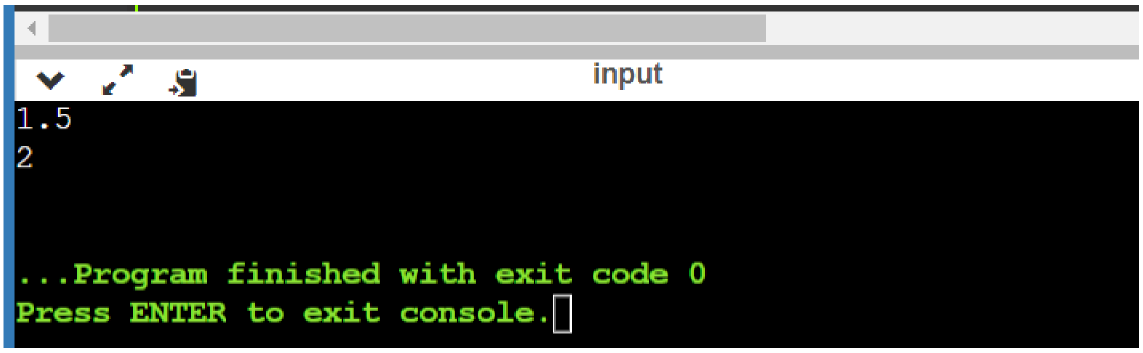

Problem Statement: The **median** is the middle value in an ordered integer list. If the size of the list is even, there is no middle value, and the median is the mean of the two middle values.

```
import heapq


class MedianFinder:
  def __init__(self):
    self.max_heap = []
    self.min_heap = []


  def addNum(self, num: int) -> None:
    heapq.heappush(self.max_heap, -num)
    heapq.heappush(self.min_heap, -heapq.heappop(self.max_heap))
    if len(self.min_heap) > len(self.max_heap):
      heapq.heappush(self.max_heap, -heapq.heappop(self.min_heap))


  def findMedian(self) -> float:
    if len(self.max_heap) == len(self.min_heap):
      return (-self.max_heap[0] + self.min_heap[0]) / 2
    else:
      return -self.max_heap[0]
```

```
medianFinder = MedianFinder()

medianFinder.addNum(1)

medianFinder.addNum(2)

print(medianFinder.findMedian())

medianFinder.addNum(3)

print(medianFinder.findMedian())
```



```
1.5
2


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```
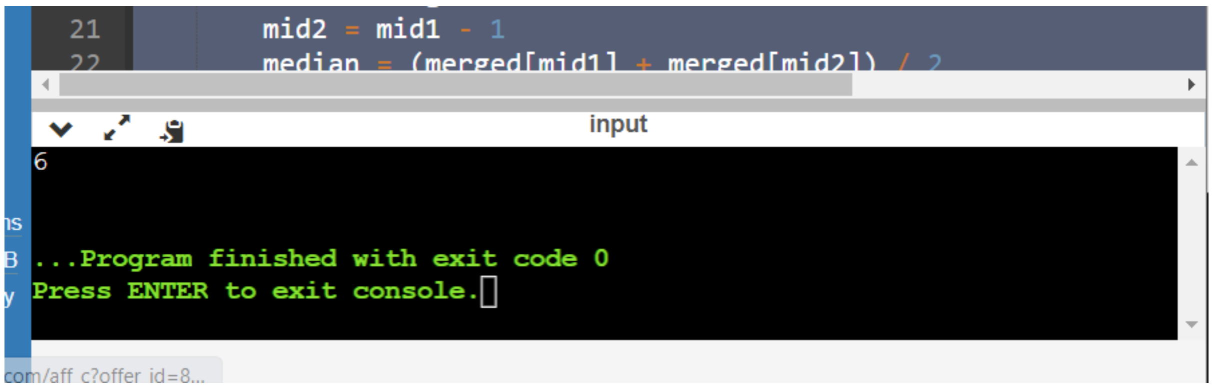

Problem Statement: Merge k sort arrays.

```
import heapq


def merge_k_sorted_arrays(arrays):

    result = []

    heap = []

    for i, arr in enumerate(arrays):

        if len(arr) > 0:

            heapq.heappush(heap, (arr[0], i, 0))



    while heap:

        val, arr_idx, idx = heapq.heappop(heap)
```

```
            result.append(val)

            if idx + 1 < len(arrays[arr_idx]):

                heapq.heappush(heap, (arrays[arr_idx][idx + 1], arr_idx, idx + 1))


    return result


arrays = [[1, 4, 7], [2, 5, 8], [3, 6, 9]]

merged_array = merge_k_sorted_arrays(arrays)

print(merged_array)
```



```
        mid2 = mid1 - 1
        median = (merged[mid1] + merged[mid2]) / 2
```

```
6


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```
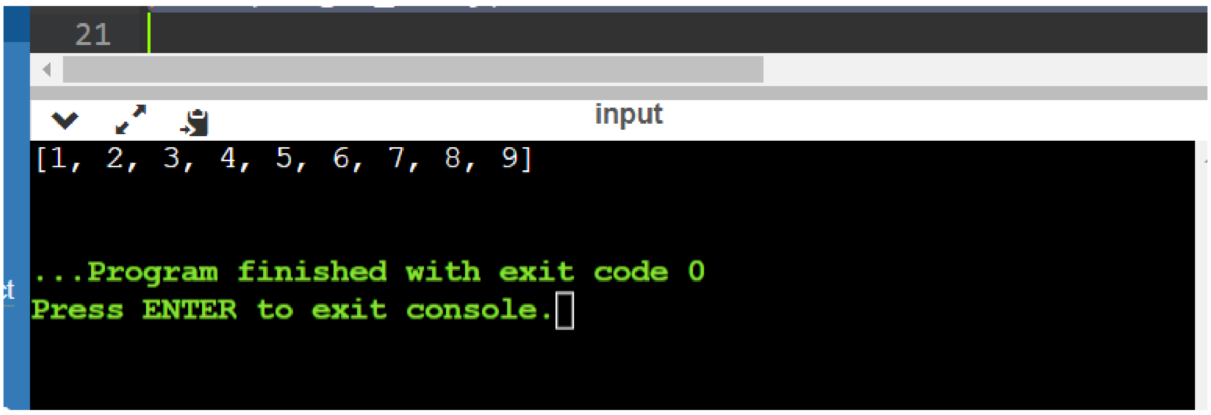

Problem Statement: Merge k sorted array

```
def find_kth_element(array1, array2, k):

    m, n = len(array1), len(array2)

    i, j = 0, 0

    count = 0


    while i < m and j < n:

        if array1[i] <= array2[j]:

            current_element = array1[i]

            i += 1

        else:
            current_element = array2[j]
            j += 1

        count += 1
        if count == k:
            return current_element

    while i < m:
        count += 1
        if count == k:
            return array1[i]
        i += 1
    while j < n:
        count += 1
        if count == k:
            return array2[j]
        j += 1

    return "Error: k exceeds the total number of elements."


array1 = [2, 3, 6, 7, 9]
array2 = [1, 4, 8, 10]
k = 5
result = find_kth_element(array1, array2, k)
print(result)
```



```
[1, 2, 3, 4, 5, 6, 7, 8, 9]


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```

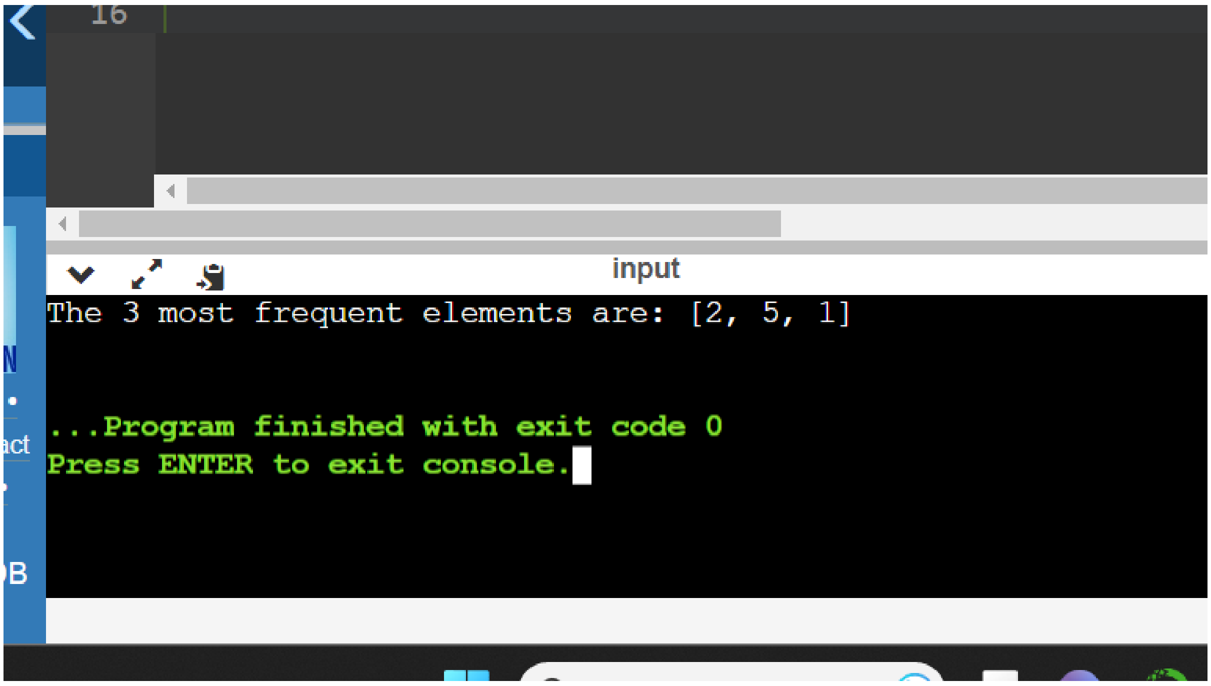
Problem Statement : k most frequent emement

```
def find_k_most_frequent_elements(nums, k):
    frequency_map = {}
    for num in nums:
        if num in frequency_map:
            frequency_map[num] += 1
        else:
            frequency_map[num] = 1
    sorted_elements = sorted(frequency_map.keys(), key=lambda x: frequency_map[x], reverse=True)
    return sorted_elements[:k]


numbers = [1, 2, 3, 2, 1, 3, 4, 5, 4, 2, 5, 5]
k = 3


k_most_frequent = find_k_most_frequent_elements(numbers, k)
```

```
print(f"The {k} most frequent elements are: {k_most_frequent}")
```



```
The 3 most frequent elements are: [2, 5, 1]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```