**Module 5– Critical Thinking Project**

# Option 2 **-** What are the properties of a heap? What is the running time of heap sort on an array A of length n that is already sorted in increasing order? What about the same in decreasing order? Lastly, trace out the heap sort algorithm for the following list: {25, 44, 55, 99, 30, 37, 15, 10, 2, 4}.

# Properties of heap

Completeness – A heap is a complete binary tree filled from top to bottom left to right.

Order - there are 2 types of heap trees; min heap and max heap and as the name suggests a min heap should have all the descendants less than the parent node and a max heap should have all the descendants greater than the parent node.

Binary tree – a heap is a complete binary tree.

## What is the running time of heap sort on an array A of length n that is already sorted in increasing order?

Regarding the time complexity for a heap – it will always be O(nlogn) irrespective of the fact weather it is sorted or not because a heap will always do the same number of swaps left to right top to bottom for the entire length of an array.

## heap sort algorithm for the following list: {25, 44, 55, 99, 30, 37, 15, 10, 2, 4}

Code

A screenshot of a computer program

Description automatically generated

## Explanation –

1. Heapify Function:
   * The heapify function maintains the max heap property for a given subtree rooted at index i.
   * It compares the parent node with its left and right children.
   * If the left or right child is greater than the parent, it swaps them.
   * The process continues recursively until the entire array satisfies the max heap property.
2. Heap Sort Function:
   * First, it builds a max heap from the input array.
   * Then, it repeatedly extracts the maximum element (root of the heap) and places it at the end of the array.
   * After each extraction, it re-heapifies the remaining elements.
   * The final result is a sorted array.
3. Example:
   * input array: [25, 44, 55, 99, 30, 37, 15, 10, 2, 4]
   * After applying heap sort, the sorted array is: [2, 4, 10, 15, 25, 30, 37, 44, 55, 99]

Git Hub - [SchoolPython/CSC506\_DAA/Module5\_HashTablesHeaps/Heapify.py at main · ArunSaxena200/SchoolPython (github.com)](https://github.com/ArunSaxena200/SchoolPython/blob/main/CSC506_DAA/Module5_HashTablesHeaps/Heapify.py)

Ref - [Introduction to Max-Heap – Data Structure and Algorithm Tutorials - GeeksforGeeks](https://www.geeksforgeeks.org/introduction-to-max-heap-data-structure/)

[6.006 Introduction to Algorithms, Lecture 8: Binary Heaps (mit.edu)](https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/40d4851e550507ca14dc778b9b2266cc_MIT6_006S20_lec8.pdf)