

1. What operations does a heap support?
2. What is the difference between a *min-heap* and a *max-heap*?
3. The following question is about building a min-heap from an array of data.
 - (a) Assume you start with an empty heap. Show the resulting min-heap structure when inserting elements in the following order: [5, 9, 11, 7, 2, 8, 19, 21, 1].
 - (b) Given the resulting heap from (a), indicate what happens if remove is called. What element is removed? What does the resulting heap structure now look like?
 - (c) Using the resulting heap from (b), show the result of one more remove.

4. For a heap with height h , what is the maximum number of swaps occurring after an insert operation? What is the minimum?

5. For a heap with k nodes, what is the maximum number of swaps occurring after an insert operation?

6. The following question is about performing a heapsort on an array of unsorted data.
 - (a) Assume we have an array of unsorted elements: $[3, 5, 1, 3, 2, 7, 9]$. Before we sort this array using heapsort, first draw a binary tree representation of this data, even though this tree will initially be an invalid heap.

 - (b) We want to sort this data using heapsort. Convert the unsorted elements into a valid min-heap structure. Use the heapify algorithm from lecture (not lab) and show both the graphical and list form of the sorted data.

(c) Show the result of the first remove operation in both graphical and list form.

(d) Show the result of the next remove operation in both graphical and list form.

7. Given a node in a heap at index k , what are the indices of both of its children? What is the index of its parent?

8. What is the overall time complexity of heapsort?