CMPSC 465 Fall 2025 | Data Structures & Algorithms Ke Chen and Yana Safonova | Quiz 3

Lecture Section: **Monday, Sep 22, 2025**

Student Name: **PSU Email ID:**

1. (2 pts.) In a **min-heap**, what is the relationship between the value of a parent node and its children?

(a) The parent node is always greater than its children.

(b) The parent node is always greater than or equal to its children.

(c) The parent node is always smaller than or equal to its children.

(d) There is no specific relationship.

Answer c) The parent node is always smaller than or equal to its children.

2. (2 pts.) Performing an IncreaseKey operation on the root of a max-heap can violate the heap property, which requires a HeapifyDown operation to restore.

(a) True

(b) False

Answer (b) False. As the maximum element is at the root of a max heap, increasing it's value does not violate heap property.

3. (2 pts.) Consider a max-heap stored in an array $A[1..7] = [7,6,4,1,5,2,3]$. After performing the following two operations in sequence, what is the resulting heap?

- IncreaseKey(6, 17)
- Insert(12)

(a) $[7,6,4,1,5,17,3]$

(b) $[17,7,12,4,1,5,2,3]$

(c) $[17,12,7,6,5,4,3,1]$

(d) $[17,12,7,5,6,4,3,1]$

Answer (c) $[17,12,7,6,5,4,3,1]$. After the `Update-Key` operation, the resulting heap will be : $[17,6,7,1,5,4,3]$. Next, insert 12 at the end and perform heapify from bottom-up and we end up with the final result $[17,12,7,6,5,4,3,1]$.

4. (2 pts.) What is the **minimum number of nodes** a **binary heap** can have, given that its height is h?

(a) 2^{h-1}

(b) $2^h - 1$

(c) 2^h

(d) $2^{h-1} + 1$

Answer (c) 2^h. A binary heap is a complete binary tree. The minimum number of nodes for a tree of height h is achieved when all levels up to $h-1$ are full, and there's only one node at level h. A full binary tree of height $h-1$ has $2^h - 1$ nodes. Adding the single node at height h gives a total of 2^h nodes.

5. (2 pts.) A programmer implemented the HeapSort algorithm discussed in lecture, but accidentally used a **min-heap** instead of a max-heap. Which of the following is the most likely outcome?

(a) The algorithm will fail to sort the array.

(b) It will sort the array in ascending order, the same as with a max-heap.

(c) It will sort the array in descending order, the opposite as with a max-heap.

(d) It will produce a correct sort, but with higher time complexity.

Answer (c) It will sort the array in descending order, which is the reverse of a max heap. Heapsort works by repeatedly extracting the root and placing it at the end of the array. With a min heap, the smallest element is at the root and it is sent to the end of the array. Doing this repeatedly result in an array sorted in descending order.