

Name: \_\_\_\_\_

1. (1 pt.) Write your name in the space provided above.
2. (11 pts.) Sort the following array in ascending order using **insertion sort**.<sup>1</sup> Depict the state of the array **after each insertion operation**, **underlining** the prefix that is known to be in sorted order, and **circling** the inserted element, similar to what was done in the classroom exercises.

i:	0	1	2	3	4	5	6	7	8	9
a[i]:	40	32	33	97	12	84	9	92	37	25

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<sup>1</sup>Mark Allen Weiss, *Data Structures and Problem Solving Using Java*, 3rd edition (Addison-Wesley, 2006), §8.3.

3. (12 pts.) What is the total number of *inversions*<sup>2</sup> in the array of Question 2? **Explain** your answer *briefly*.

The array is repeated here for reference:

i:	0	1	2	3	4	5	6	7	8	9
a[i]:	40	32	33	97	12	84	9	92	37	25

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<sup>2</sup>*Idem*, p. 307.

4. (12 pts.) Using conventional graphical notation, depict the complete binary **tree encoded** by the array of Question 2, based on the textbook's method **as used for heapsort**.<sup>3</sup> **Mark the edges** that violate the *heap-order property* (for **max**-heaps) by an **X**.

The array is repeated here for reference:

i:	0	1	2	3	4	5	6	7	8	9
a[i]:	40	32	33	97	12	84	9	92	37	25

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<sup>3</sup>*Idem*, §21.5.

5. (12 pts.) *Heapify* the tree of Question 4 using the *buildHeap* operation from the textbook.<sup>4</sup> Depict intermediate states of the tree, **including at least** the states after *buildHeap* completes each level of the tree. **Mark parent-child swaps** by annotating the corresponding edges with an X.

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<sup>4</sup>*Idem*, §21.3.

[additional space for answering the earlier question]

6. (12 pts.) Suppose the keys in the array of Question 2 are inserted, in the order  $a[0] \dots a[9]$ , into a hash table  $t[0] \dots t[22]$ , using the **hash function**  $h(x) = x \bmod 23$  and the **quadratic probing** for collision resolution. Depict the final state of the hash table  $t$ .

The array is repeated here for reference:

i:	0	1	2	3	4	5	6	7	8	9
a[i]:	40	32	33	97	12	84	9	92	37	25