

Student Name:

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Part A [32 Points] There are 8 multiple-choice questions in this part.

To choose an answer, simply draw a circle around the bullet (•) of the answer chosen (if any!). A correct choice for one question will get 4 point. An incorrect answer or marking several answers for a question will get -1. The minimum total mark for this part is 0.

- * An Algorithm $C1(n)$ uses $10n \log_2 n$ operations and $C2(n)$ uses $n^2 + 512$ operations. Which of the following values for n_0 is the **smallest** such that $C2(n) \geq C1(n)$ for all $n \geq n_0$?

• 64 • 128 • 16 • 32

- * Consider the following pseudo code:

$a \leftarrow 0$

for $i \leftarrow 0$ **to** $n*n$ **do**

for $j \leftarrow 0$ **to** i **do** $a \leftarrow a + i$

Which of the following characterization, in terms of n , of the running time of the above code is **not** correct?

• $\Omega(n^2)$ • $O(n^5)$ • $\Theta(n^4)$ • $O(n^3)$

- * Assume the Sequence ADT based on a circular array implementation. Which of the following operations requires $O(n)$ steps?

- atRank
- replaceAtRank
- remove
- elemAtRank

- * Consider a sequence S implemented with a non-circular array. Suppose further that $S = (0, 1, 2, 3, 4, 5, 6, 7, 8, 9)$, in that order, so that each element is actually equal to its rank. Which of the following statements about elemAtRank and insertAtRank is **correct**?

- $S.remove(9)$ has the longest runtime
- $S.elemAtRank(9)$ has the longest runtime
- $S.insertAtRank(0, 11)$ has the longest runtime
- $S.insertAtRank(0, 11)$ has the shortest runtime

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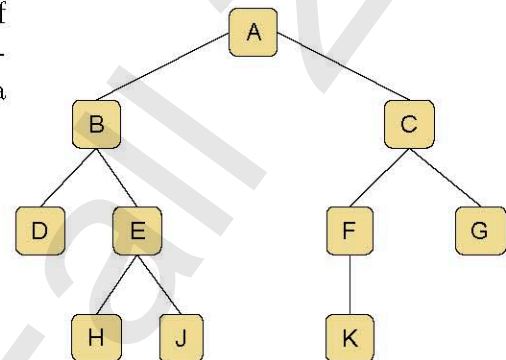
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- * Consider the following List ADT operations (where the p_i 's represent positions):
 $p_1 = \text{insertFirst}(8)$, $p_2 = \text{insertAfter}(p_1, 5)$, $p_3 = \text{insertBefore}(p_2, 3)$, $p_4 = \text{insertFirst}(9)$,
 $\text{remove}(p_4)$, $\text{swapElements}(p_1, p_2)$, $\text{replaceElement}(p_3, 7)$, $p_5 = \text{insertAfter}(\text{first}(), 2)$.
 Which of the following options describes the final list in a **correct** way?

- (8,5,3,9)
- (5,7,3,2)
- (5,2,7,8)
- (3,7,5,9)

- * Which of the following chronological sequences of node names does **not** correctly represents a traversal of the tree to the right that corresponds to a preorder or inorder or postorder traversal?

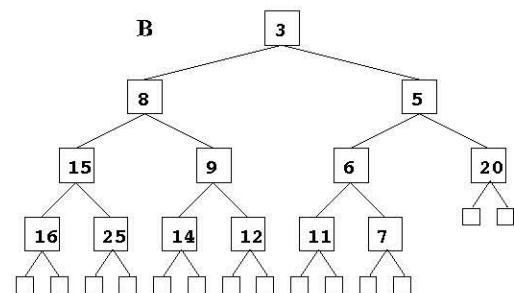
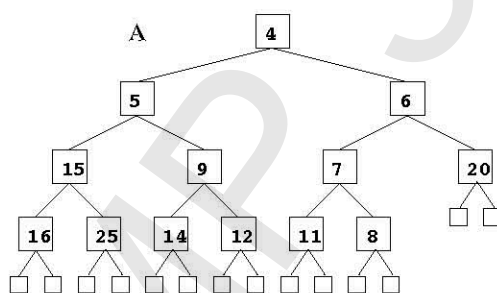
- A,B,D,E,H,J,C,F,K,G
- D,H,J,E,B,K,F,G,C,A
- A,B,E,H,J,K,D,C,F,G
- D,B,H,E,J,A,K,F,C,G



- * Which of the following options list the functions in **correct** non-decreasing order if they are compared by asymptotic growth?

- $\log n, n, n \log n, n^2 + \log n, n - n^3 + 7n^5, 2^n, n^n, n!$
- $\log n, n, n \log n, n^2 + \log n, n - n^3 + 7n^5, 2^n, n!, n^n$
- $\log n, n, n \log n, n^2 + \log n, n - n^3 + 7n^5, n!, 2^n, n^n$
- $\log n, n, n \log n, n - n^3 + 7n^5, n^2 + \log n, 2^n, n^n, n!$

- * What is the **correct** sequence of **insert** and/or **removeMin** operations on heap A that will transform it into heap B (as shown below)?



- `insert(7), removeMin()`
- `removeMin(), removeMin(), insert(3)`
- `removeMin(), insert(3)`
- `removeMin(), insert(3), insert(5)`

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B.1 [20 Points] Write in pseudo code a tail-recursive algorithm “reverse” using the Sequence ADT that creates from a given sequence a new copy in reverse order. For instance, if S1 represents the sequence (1,2,3), then $S2 := \text{reverse}(S1)$ returns a sequence that represents (3,2,1) but leaves S1 unchanged.

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B.2 [24 Points] The *Towers of Providence* is a variation of the classical Towers of Hanoi problem. There are four pegs, denoted A , B , C , and D , and n disks of different sizes. Originally, all the disks are on peg A , stacked in decreasing size from bottom to top. Our goal is to transfer all the disks to peg D , and the rules are that we can only move one disk at a time, and no disk can be moved onto a smaller one. Write a recursive algorithm in **pseudo code** that solves the *Towers of Providence* problem.

Hint: use the operator ‘&’ to concatenate elements and lists, the functions $\text{first}(L)$ which returns the first element of a list L , $\text{rest}(L)$ which return the list L without its first element, and the predicate $\text{empty}(L)$ which is true if L does not contain an element.

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Part C [24 Points] For each of the 4 questions in this part, mark **T** if the given statement is **ALWAYS** true. Otherwise mark **F** and **justify** your answer. If you do not justify the FALSE case you will lose marks. There is **no penalty** for selecting the wrong answer.

Hint: A correct counter example or the correct specification will give you the full mark.

- If $f(n)$ and $g(n)$ are both $O(h(n))$, then $f(n) + g(n)$ is **not** $O(h(n))$. ☐ **T** ☐ **F**

- If x and y are real numbers such that $0 < x < y$ then n^x is $O(n^y)$ and n^y is $O(n^x)$.
☐ **T** ☐ **F**

- A preorder traversal of a heap yields the keys in nondecreasing order. ☐ **T** ☐ **F**

- if $f(n)$ is $\Omega(n)$ and $O(n)$, then $f(n)$ is $\Theta(n)$. ☐ **T** ☐ **F**