Exam – Sample Questions

CS 151: Algorithms and Data Structures

NOTE: the actual exam will contain around 20-25 questions.

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1. Consider a LinkedList that has a `get(int i)` method to return the i-th element in the list. Write pseudocode to implement the method. Next, analyse (in order-notation, in terms of n) the following code:

```
LinkedList L;
// ... LinkedList is initialized and now contains n items (code not shown).
for (int i=1; i<=n; i++) {
    sum = sum + L.get(i);
}
```

2. Consider this snippet of code:

```
int[][] A = new int [n][];
for (int i=0; i<n; i++) {
    if (i % 2 == 0) // i is a multiple of 2
        A[i] = new int [n];
    else
        A[i] = new int [1];
}

for (int i=0; i<A.length; i++)
    for (int j=0; j<A[i].length; j++)
        sum = sum + A[i][j];
```

   It's running time is:

   (a) $O(n \log n)$.

   (b) $O(n)$.

   (c) $O(n^2)$.

   (d) $O(\frac{n}{2})$.

3. Suppose $f(n) = 3n^3 + 2n^2 + n$. Consider these statements:

   I $\quad f(n) = O(n^3)$.

   II $\quad f(n) = O(n^4)$.

(a) Only I is true.
(b) Only II is true.
(c) I and II are both true.
(d) I and II are both false.

4. The ratio of the running time of Bubble-Sort to that of Merge-Sort is:
   (a) $O(n \log n)$.
   (b) $O(\frac{n}{\log n})$.
   (c) $O(\log \frac{n^2}{\log n})$.
   (d) $O(1)$.

5. Consider the following input with 10 keys (each is a letter) to QuickSort.

   K G I K N V S S W Q

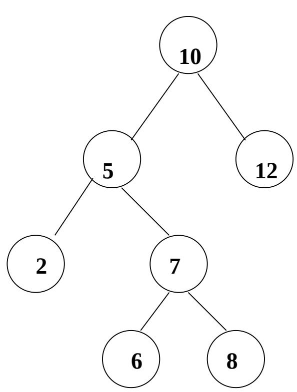
   Assume the leftmost element is the partitioning element. Show the array after the partitioning step is complete.

6. Suppose the indices of the array that implements a binary heap start from 1. Now consider these assertions about finding the indices of the parent and left-child of the i-th element:

   I parent(i) $= i/2$.
   II left(i) $= 2i + 1$.

   (a) I and II are both true.
   (b) Only I is true.
   (c) Only II is true.
   (d) I and II are both false.

7. Delete 5 from this binary tree:



8. Insert the bitstrings 100, 110, 011 and 010 into a simple trie.

9. Consider the statements

I	In a simple trie, all the keys are at the leaves.
II	In a full trie, all the keys are at the leaves.

   (a) I and II are both true.

   (b) Only I is true.

   (c) Only II is true.

   (d) I and II are both false.

10. Draw an NDFA for the regular expression `C(AB)*(A|C)`

11. Suppose the height of a binary tree with one node is defined to be 1. A complete binary tree of height h has

   (a) 2^h edges.

   (b) $2^h - 1$ edges.

   (c) $2^h - 2$ edges.

   (d) 2^{h+2} edges.

12. A ring is a connected undirected graph in which all the nodes form a ring (thus, each node has exactly two neighbors). The running time of Prim's algorithm, using an adjacency list, on this graph is:

   (a) $O(V \log V)$

   (b) $O(V^2 \log V)$

   (c) $O(V^2)$

   (d) $O(V^3)$

13. Consider these two statements about a connected undirected graph with V vertices and E edges:

I	$O(V) = O(E)$
II	$O(E) = O(V^2)$

   (a) I and II are both false.

   (b) Only I is true.

   (c) Only II is true.

   (d) I and II are both true.

14. Consider the following two statements about an undirected graph with n vertices:

I	If every pair of vertices has an edge, there are exactly $\frac{n(n+1)}{2}$ edges.
II	If the graph has a spanning tree, the tree must have $\Theta(n)$ edges.

(a) I and II are both true.

(b) Only I is true.

(c) Only II is true.

(d) I and II are both false.

15. Suppose the shortest path from node i to node j goes through node k and that the cost of the subpath from i to k is D_{ik}. Consider these two statements:

I	Every shortest path from i to j must go through k.
II	Every shortest path from i to k has cost D_{ik}.

(a) I and II are both true.

(b) Only I is true.

(c) Only II is true.

(d) I and II are both false.

16. Consider the contiguous load balancing problem where s_i is the execution time of task i and let D_i^k be the optimal cost in assigning tasks $0, \ldots, i$ on to k processors. Then, the dynamic programming recurrence can be stated as:

(a) $D_i^k = \max_j \min(D_j^{k-1}, \sum_{l=j+1}^{i} s_l)$.

(b) $D_i^k = \max_j \min(D_{j-1}^{k}, \sum_{l=j+1}^{i} s_l)$.

(c) $D_i^k = \max_j \max(D_j^{k-1}, \sum_{l=j+1}^{i} s_l)$.

(d) $D_i^k = \min_j \max(D_j^{k-1}, \sum_{l=j+1}^{i} s_l)$.

17. Consider the execution times of two algorithms I and II:

I	$O(n^{\log n})$
II	$O(\log(n^n))$

(a) Only I is polynomial.

(b) Only II is polynomial.

(c) I and II are both polynomial.

(d) Neither I nor II is polynomial.

18. For a travelling salesman problem with n cities, the number of possible tours is:

(a) $\frac{n!}{2}$

(b) $\frac{(n-1)!}{2}$

(c) $\frac{n(n-1)}{2}$

(d) $\frac{n(n+1)}{2}$

19. Consider the following statements about NP-completeness:

I	NP-completeness only applies to combinatorial optimization problems.
II	An NP-complete problem cannot be solved in polynomial-time.

(a) Only I is true.

(b) Only II is true.

(c) I and II are both true.

(d) Neither I nor II is true.

20. Consider the following statements about NP-completeness:

I	The traveling salesman problem is NP-complete.
II	The minimum-spanning tree problem is not NP-complete.

(a) Only I is true.

(b) Only II is true.

(c) I and II are both true.

(d) Neither I nor II is true.

21. Consider the following statements about estimation:

I	The sample mean is always larger than the sample variance.
II	It is possible for the sample variance to be zero.

(a) Only I is true.

(b) Only II is true.

(c) I and II are both true.

(d) Neither I nor II is true.