This exam is **no book, no notes, no gadgets**. You have the full period (50 minutes). There are 23 questions, worth 0 total points. Marks will be curved so the median is B at least.

Name (Print): ____________________________________

This exam is my own work. I understand it is governed by the ***Emory Honor Code****.*

Signature: ____________________________________

Multiple Choice: choose the best answer for each.

(2 pts) 1. We added random edges to a graph until it was connected. Which of these told us when to stop?
A. BFS B. CC C. DFS D. SCC E. UF

(2 pts) 2. In the particle system simulation, what kind of data structure stores the future events?
A. an array B. some BST C. hash table D. a heap E. UF

(2 pts) 3. In SymbolGraph (which reads `movies.txt`), what maps vertex names to numbers?
A. an array B. some BST C. hash table D. a heap E. UF

(2 pts) 4. In SymbolGraph, what data structure maps vertex numbers to names?
A. an array B. some BST C. hash table D. a heap E. UF

(2 pts) 5. Who invented our method for BST deletion?
A. Floyd B. Hibbard C. Knuth D. Sedgewick E. Tarjan

(2 pts) 6. Where does BFS keep track of the vertices it needs to visit next?
A. explicit stack B. runtime stack C. fifo queue D. priority queue E. marked array

(2 pts) 7. What DFS edge type cannot occur in the traversal of an undirected graph?
A. back B. cross C. forward D. parallel E. tree

(2 pts) 8. What DFS edge type cannot occur in the traversal of an acyclic digraph (DAG)?
A. back B. cross C. forward D. parallel E. tree

(2 pts) 9. Which is NOT found using DFS?
A. bridges B. connected components C. cycles D. shortest paths E. topological order

(2 pts) 10. Which red edge arrangements cannot occur during insertion in a left-leaning red-black tree?
Choose **TWO** of these: A.  B.  C.  D.  E. 

Fill in the Blank: partial credit is sometimes possible.

(2 pts) 11. Suppose we store a binary heap in an array, with the root at index 1. If a node is at index j, the right child of that node is at what index?

11. ____________________

(2 pts) 12. After a full DFS traversal of a DAG, we can get a topological sort by listings its vertices in what order?

12. ____________________

(2 pts) 13. What algorithm from the book could be made faster by running a DFS for just one vertex per SCC, as observed in class?

13. ____________________

(2 pts) 14. Given a graph with V vertices and E edges, how much extra space (beyond the graph itself) is used by DFS? (Use big-Oh.)

14. ____________________

(2 pts) 15. Sarnak and Tarjan designed a partially persistent version of what data structure?

15. ____________________

(2 pts) 16. `TopM` computes the `M` largest of `N` input numbers using $O(\texttt{M})$ space, and how much time? (Use big-Oh.)

16. ____________________

(2 pts) 17. The BST `rank` and `select` methods rely on what extra data field (beyond key, value, left, right), present in each node?

17. ____________________

(2 pts) 18. The fail-fast `TreeMap` iterators check that what field (of the `TreeMap`) still has its expected value?

18. ____________________

(2 pts) 19. Which hashing method allows deletion in worst-case time $O(1)$?

19. ____________________

(2 pts) 20. We observe clustering in which hashing method?

20. ____________________

Short Answer.

(6 pts) 21. Describe a situation where we need a family of hash functions (from which we can pick one at random), rather than just one fixed hash function.

(6 pts) 22. Consider digraph H on the board. Assume its adjacency lists are in sorted order. Consider a DFS traversal of H (so at the top level, we start a DFS at each unmarked vertex). Draw H, indicating the tree edges, and also the "pre-order" labels (in other words, write `pre[v]` next to each `v`).

(4 pts) 23. Supposing H is the reverse of G, and we are using Kosaraju's algorithm to compute the SCC's of G. In the second DFS traversal, in what order would the algorithm consider the vertices of G? (Write down the ordering.) Also, indicate the SCC's of G (just as subsets, you do not need to draw trees).