This exam is no book, no gadgets. You are allowed one sheet of notes (letter size, two sides), which you should turn in with the exam. There are 33 questions, worth 70 total points. Marks will be curved so the median grade is at least B.

Name (Print): Solutions

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

Signature: ____________________________

Fill in the Blank: fill each blank appropriately.

(2 pts) 1. Suppose we need to build a long String by appending many char values. What standard Java class helps us to do this efficiently?

1. **StringBuilder or StringBuffer**

(2 pts) 2. What priority queue (a Java class from our book) lets us decrease the priority of an existing key?

2. **IndexMinPQ**

(2 pts) 3. What priority queue (mentioned but not implemented by our book) lets us decrease the priority of an existing key in O(1) amortized time?

3. **Fibonacci heap**

(2 pts) 4. Which hashing scheme allows load factors larger than one?

4. **(separate) chaining**

(2 pts) 5. Which hashing scheme guarantees both search and delete in worst-case constant time?

5. **Cuckoo or perfect**

(2 pts) 6. Kruskal’s MST algorithm uses a priority queue (for edges), and what other data structure?

6. **UF or union-find**

(2 pts) 7. Which MST algorithm uses only O(V) extra space?

7. **eager Prim**

(2 pts) 8. Which single-source shortest paths algorithm is best when all edges have weight one?

8. **BFS**

(2 pts) 9. Which single-source shortest paths algorithm is best when there are no negative edge weights?

9. **Dijkstra**

(2 pts) 10. Which single-source shortest paths algorithm is best in a DAG?

10. **Acyclic or Topological**
(2 pts) 11. Which single-source shortest paths algorithm is best when there are cycles and negative edges?

11. Bellman-Ford

(2 pts) 12. Which all-pairs shortest paths algorithm is best in a sparse graph with negative edge weights?

12. Johnson

(2 pts) 13. In hw4 our input was \( N \) points in the plane. What data structure did we use to quickly list the points nearest a given query point?

13. Quad Tree

(2 pts) 14. Suppose we have \( N \) points in the plane, \( M \) is the weight of their Euclidean MST, and \( T \) is the weight of their best TSP tour. What inequality did we state, relating \( M \) and \( T \)?

14. \( M \leq T \) or \( T \leq 2M \)

(2 pts) 15. Which string sorting algorithm uses both key-indexed counting and recursion?

15. MSD

(2 pts) 16. Which string sorting algorithm uses key-indexed counting without recursion?

16. LSD

(2 pts) 17. Which string sorting algorithm uses recursion without key-indexed counting?

17. 3-way (radix) quicksort

(2 pts) 18. In the KMP DFA for pattern “ABABABC”, what is the restart (or “trailing”) state for state 6?

Note: ‘X’ in the code

18. 4

(2 pts) 19. What is the total time to search for a substring of length \( M \), in a text of length \( N \), with an alphabet of size \( R \), using the KMP DFA approach? (Big-Oh, including time to build DFA.)

19. \( O(MR + N) \)

(2 pts) 20. Which substring search algorithm relies on a random hash function?

20. Rabin-Karp

(2 pts) 21. Which substring search algorithm can run in \( O(N/M) \) time, for some inputs?

21. Boyer-Moore

(2 pts) 22. What data structure did Choi propose, for storing the children of a trie node?

22. HashMap

(2 pts) 23. If we store \( N \) random strings from an alphabet of size \( R \) in an \( R \)-way trie, what is the expected number of chars examined for a search miss?

23. \( \log_R N \)
24. If we sort $N$ random strings from an alphabet of size $R$ using 3-way quicksort, what is the expected number of char comparisons?

24. $2N \ln N$ or $1.39 N \log N$

25. In hw5, which suffix (or cyclic shift) sorting algorithm did we use, to implement a faster Burrows-Wheeler transform (BWT)?

25. Manber

26. What is the BWT of “santas”, adding the mark character ‘%’? (Note ‘%’ is first in sorted order.)

26. SSTAA%TN

27. What is reverse BWT of “rceacra”, removing the mark character ‘e’?

27. Carrac

28. What is the (big-Oh) time required to compute the reverse BWT of a string of length $N$ over an alphabet of size $R$, using the method from homework?

28. $O(N^2R)$

29. What string is encoded by the LZW codes 41, 81, 42, 82, 80? (As usual 41 is A, 42 is B, 80 is end-of-file, and 81 is the first available code.)

29. AAAAAAAAA

30. Suppose we use Huffman coding on the text “Yehoho!” (without quotes). What is the bit length of the compressed text? (Just the text, no tree.)

30. 13

31. This data structure is a compressed trie, storing all the suffixes of a given input string.

31. Suffix tree

-1: patricia

Short Answer:

32. Suppose we use MSD to sort the following eight strings. Underline the characters that are NOT examined:

BIG BAD BEAR BE THE BIG BOY BAND

33. Draw the TST that results from inserting the previous list of strings, in order. The first string (BIG) has value 0, the second has value 1, and so on.