CS 2150 Final Exam

Name _____

You MUST write your e-mail ID on **EACH** page and bubble in your userid at the bottom of this first page. And put your name on the top of this page, too.

If you are still writing when "pens down" is called, your exam will be ripped up and not graded – even if you are still writing to fill in the bubble form. So please do that first. Sorry to have to be strict on this!

Other than bubbling in your userid at the bottom of this page, please do not write in the footer section of this page.

There are 10 pages to this exam. Once the exam starts, please make sure you have all the pages. Questions are worth different amounts of points.

If you do not bubble in this first page properly, you will not receive credit for the exam!

This exam is CLOSED text book, closed-notes, closed-calculator, closed-cell phone, closed-computer, closed-neighbor, etc. Questions are worth different amounts, so be sure to look over all the questions and plan your time accordingly. Please sign the honor pledge below.

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All shortcuts have disappeared.
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Page 2: Lists & Numbers

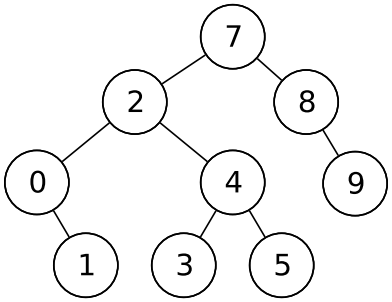
1. [3 points] *Why* does a vector have $\Theta(1)$ amortized running time? We are looking for an answer that talks about how a vector works, not a description of what amortized means.

2. [3 points] Convert -99 to two's complement little-Endian hexadecimal notation.

3. [6 points] Convert -0.375 to IEEE 754 floating-point notation.

Page 3: Trees & Hashes & IBCM

4. [3 points] Insert 6 into the AVL tree below. Show the resulting data structure.



5. [3 points] What is the running time of a hash table (for insert, remove, and find) that uses a probing strategy as the collision resolution protocol?

6. [6 points] We have seen how IBCM performs one-dimensional array subscripting. List the IBCM commands to perform two-dimensional array subscripting? Assume that the array base address is at a, it has r rows and c columns, and you want value $a[x][y]$. Your commands should be left in opcode form. You may use any other variables that you wish, but briefly explain what they are if it is not obvious. Please only include the IBCM commands requested – we are not looking for a complete IBCM program.

Page 4: x86

7. [3 points] List three assembly-level optimizations that g++ makes when compiling (and optimizing) code into assembly.

8. [3 points] How would you modify the C calling convention to reduce the possibility of buffer overflow attacks?

9. [3 points] Why are the parameters pushed onto the stack in reverse order?

10. [3 points] List one part of the C calling convention that would be different (or not necessary, etc.) for Java, and explain why this is the case.

Page 5: Memory

11. [6 points] Write a program segment (no subroutines, #includes, namespaces, etc.) that works *against* the cache. In other words, write a program segment that causes a cache miss very often. This should be a short program – if it is longer than 10 lines, we won't grade it! You can assume that your cache is 1 Kb in size.

12. [6 points] We have studied two ways that a computer can allocate space on the heap – fixed-sized block allocation and buddy blocks. In the former, the heap directory structure is just an array of allocated blocks. Describe what would be a likely data structure for buddy blocks. You need to describe *how* the allocations (via `new`) and deallocations (via `delete`) would work – just saying it's a "binary tree" will receive zero credit.

Page 6: C++

13. [3 points] Why would you want to inherit something via `private` inheritance?

14. [3 points] When the `virtual` keyword is *not* present anywhere in the class hierarchy, how does C++ determine which method to call?

15. [3 points] What is the difference between shared multiple inheritance and replicated multiple inheritance?

16. [3 points] List (and very briefly describe) two changes in C++11 that are not in the current version of C++.

Page 7: Heaps & Huffman coding

17. [3 points] Why is an insert into a binary heap typically a constant time operation, even though the worst case is still $\Theta(\log n)$?

18. [9 points] Construct the Huffman coding tree for the following sentence: "i like cake" (no quotes). Include spaces as well. You need to show a few intermediate steps: the frequency count and the min-heap.

Page 8: Graphs

19. [6 points] We have studied Dijkstra's algorithm for finding the shortest path. One of the assumptions for Dijkstra's algorithm is that there are no negative cost edges. For this question, you will need to design an algorithm to find the shortest path in a graph that *does* have negative cost edges. You may assume that there are no negative cost cycles, and that the graph is fully connected. You can list it as English steps or as a paragraph – no need to write C++ code. What is the running time of your algorithm?

20. [3 points] Give two real-world applications of minimum spanning trees.

21. [3 points] For an unweighted graph, we can either use Dijkstra's algorithm to find the shortest path, or breadth-first search. Which is faster? Why?

Page 9: Demographics

Name: _____

We meant to ask these in an end-of-the-semester survey, but we did not get to it in time. So we'll put it here for some extra points on the exam!

22. [0 points] Did you put your name and userid at the top of this page? You need to in order to get the points on this page.

23. [2 points] What is your major or minor (if you have not declared, then your intended major or minor)? Please circle one.

    - BS CS
    - BA CS
    - BS CpE
    - CS minor
    - Neither majoring nor minoring in computing
    - Other (please explain): _____

24. [2 points] What CS 1 class did you take? Please circle one.

    - CS 1110 (a.k.a. CS 101)
    - CS 1111 (a.k.a. CS 101-E)
    - CS 1112 (a.k.a. CS 101-X)
    - CS 1120 (a.k.a. CS 150)
    - AP credit
    - Transfer credit
    - Placed out of it via the CS 101/1110 placement exam
    - Other (please explain): _____

25. [2 points] If you took your CS 1 class in college (i.e. CS 101/1110, 101-E/1111, 101-X/1112, 150/1120, or a transfer class), in what semester did you take it?

26. [2 points] What CS 2 class did you take? Please circle one.

    - CS 2110 (a.k.a. 201)
    - CS 2220 (a.k.a. 205)
    - AP credit
    - Transfer credit
    - Other (please explain): _____

27. [2 points] If you took your CS 2 class in college (i.e. CS 201/2110, 205/2220, or a transfer class), in what semester did you take it?

28. [2 points] Did you attend the final exam review session? You'll get full credit for this question, as long as you answer it honestly (we know most of the people that were there, but not all).

Page 10: When Dijkstra's shortest path algorithm fails...

(from `http://xkcd.com/461/`)