Computer Science 302 Fall 2009 (Practice) Second Examination, October 15, 2009

Name:____

The entire examination is 450 points.

1. True or False. [5 points each]

   (a) ________ A good programmer should never use linear search.

   (b) ________ If a collision occurs in a hash table, there must be some error in the implementation.

   (c) ________ If an array has size n, and $\frac{n}{2}$ of its entries are zero, we would say that is a sparse array.

   (d) ________ The height of an AVL tree with n nodes is $O(\log n)$.

   (e) ________ The height of a 2-3 tree with n nodes is $O(\log n)$.

   (f) ________ A *stack* is an example of a *search structure*.

   (g) ________ An item can always be inserted into a min-heap of size n in $O(\log n)$ time.

   (h) ________ A *treap* is an example of a *priority queue*.

2. Fill in the blanks (5 points each blank).

   (a) *Probing* is used in ______________________________ hashing.

   (b) A ______________________________ hash table is designed so that the size of the table is exactly the number of data and there are no collisions.

   (c) A 2-3 tree which holds 400 data items must have height at least ________ and at most ________. (Exact answers, please.)

   (d) A condition that is

      i. True for the first iteration of a loop, and

      ii. true at the end of any iteration of that loop, provided it is true at the beginning of that iteration,

   is called a ______________________________ of that loop. [2 word answer]

   (e) You need to design a hash function for a hash table that will be used for a set of data items. As the program runs, new data items will be added. Your hash function should satisfy the following three conditions.

      i. ____

      ii. ____

      iii. ____

(f) For each of the following blanks, the correct answer is *stack*, *queue*, *list*, *array*, *heap*, or *search structure*.

   i. *pop* is an operator of ______________ .

   ii. *fetch* is an operator of ______________ .

   iii. While a program is running, *activation records* for all currently open subprograms are stored in a ______________.

   iv. *find* is an operator of ______________ .

   v. You would use a ______________ to do breadth first search.

   vi. You would use a ______________ to hold the records of the customers of a business.

   vii. You would use an ______________ to keep track of the number of times each word occurs in a Shakespeare play.

   viii. You would use a ______________ to match left with right parentheses in an algebraic expression.

   ix. Every time you get money, you pay as many bills as possible, in order of urgency. Urgency is determined by due date, not the date that you received the bill.
   You would use a ______________ to store your unpaid bills.

[20 points] Build a binary search tree, starting from an empty tree, inserting the following items one at a time: **Moe Abe Joe Nan Ted Kim Sam Ron Dan Sue Zed**. Once an item is inserted into the tree, it is not moved.

3. [25 points] Explain how you would use a search structure to implement a sparse array.

4. (a) [10 points] An array A has base address 1024 and length 100. The indices start at zero, just as in C++. Each item takes one addressable space. What is the address of $A[34]$?

   (b) [20 points] A $7 \times 20 \times 15$ array B has base address 1136. The indices start at zero, just as in C++. B is stored in column major order, and each item takes two addressable spaces. What is the address of $B[3, 7, 11]$?

5. [30 points] In FORTRAN, all matrices (*i.e.*, arrays) are stored in column-major order, and indices always start at 1 (not 0, as with C++). A FORTRAN program contains a declaration for a $10 \times 8 \times 20$ 3-dimensional matrix of type FLOAT, called `A`. Each variable of type FLOAT uses two words (address locations).

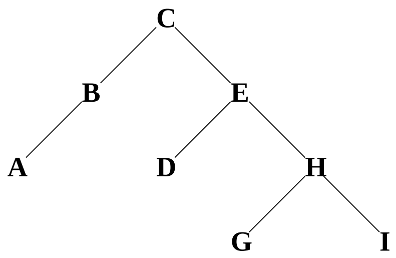
   The compiler allocates a block of space, starting with word 1025, for `A`. Where will the variable `A(5,4,16)` be stored? (FORTRAN uses parentheses instead of brackets to indicate array indices.)

6. [20 points] Suppose that the items of a queue are A, H, K, B, T in that order, where A is the front item.

   (a) Sketch the appearance of a circular linked list implementation of that queue.

   (b) Insert the item L into that queue. Show the steps. (You should draw at least two additional figures.)

7. Consider the following AVL tree T.

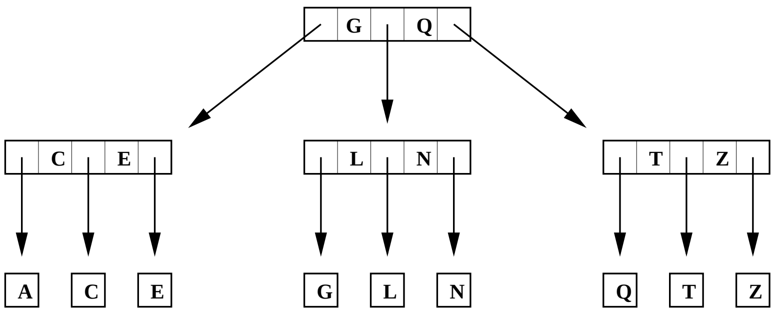


   (a) [10 points] An AVL tree should have some additional data, missing in this figure, at each node. Draw in those missing data.

   (b) [10 points] List the nodes of T in preorder, inorder, postorder, and level order.

   (c) [20 points] Insert **F** into T, and rebalance. Show the steps.

8. [30 points] Consider the 2-3 tree illustrated below. Illustrate the tree after the letter **J** is inserted. (You are not required to show steps, but it doesn't hurt.)



9. [30 points] Consider the heap of 12 elements, implemented as an array as illustrated below. Illustrate the implementation after insertion of the letter **E**. (You are not required to show steps, but it doesn't hurt.)

B	**M**	**K**	**Q**	**N**	**S**	**L**	**Z**	**W**	**P**	**R**	**U**	**X**	**B**	**V**	**W**	**K**	**A**

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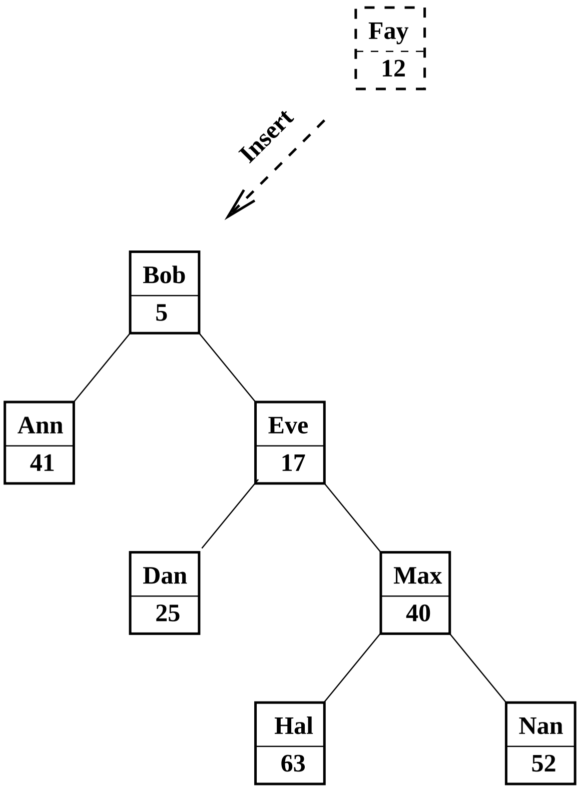
10. [30 points] Consider the treap illustrated below, where the heap key is a randomly chosen integer in the range $0 \ldots 99$. A new item, "Fay," is inserted, and the heap key "12" is chosen. Show the treap after that insertion. Show the intermediate steps.



11. [20 points] You are building a cuckoo hash table for the following data set consisting of 8 items. The indices of your has table are $\{0, 1, \ldots 9\}$. The two hash values for each item are listed in the first and second columns of the array below.

    Walk through the steps of inserting the items, in the order given in the array.

Ann	1	4
Dan	8	7
Kim	2	8
Sam	5	2
Zoe	3	9
Ted	5	0
Kat	8	2
Max	3	4

12. [30 points] You wish to send out a mass mailing to a large number of customers, all of whom are in the United States. You have a file consisting of records, where each record contains the name and address of a customer, including zip code. There are no duplicate entries in the file.

    In order to get a discount from the postal service, you want to bundle them by zip code. Describe a bucket sort algorithm which handles this problem.

    Do not attempt to write actual code; rather, I want you to describe your algorithm mostly in words and possibly pictures.

13. [20 points] Walk through Kruskal's algorithm to find a minimum spanning tree for the weighted graph shown below.