# CS140 -- Final Exam. December 10, 2008

**Please, write your answers on a separate sheet, not on the exam.**

**Remember your name, too...**

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## Question 1

Behold the following B-tree for $M = 5$.


- **Part 1**: Draw the B-tree that results when you insert the value 6 into the tree.
- **Part 2**: Explain why a B-tree would have different values of $M$ for internal and external nodes of the tree.

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## Question 2

You are given the hash table on the right.

- **Part 1**: Suppose you are using Linear Probing. Draw the hash table that results when you insert the keys "Teachers" and "Critics", which have hash values of 47 and 170 respectively.
- **Part 2**: Use the hash table on the right to demonstrate why quadratic probing can be a disastrous collision resolution technique if you don't select your parameters properly. Use a detailed example, and then tell me how you would change things to make quadratic probing work.
- **Extra Credit**: Who wrote the song?

| | |
|---|---|
| 0 | Not |
| 1 | Are |
| 2 | We |
| 3 | |
| 4 | |
| 5 | Homo |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | Jocko |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | Pins? |

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## Question 3

Let $f(x) = 2x$, $g(x) = 100x$, $h(x) = |x - 3|$, and $j(x) = -|x - 3|$. Which of the following are true (answer all that are true, not just one):

| | | | |
|---|---|---|---|
| A: $f(x) = O(g(x))$ | D: $g(x) = O(f(x))$ | G: $h(x) = O(f(x))$ | J: $j(x) = O(f(x))$ |
| B: $f(x) = O(h(x))$ | E: $g(x) = O(h(x))$ | H: $h(x) = O(g(x))$ | K: $j(x) = O(g(x))$ |
| C: $f(x) = O(j(x))$ | F: $g(x) = O(j(x))$ | I: $h(x) = O(j(x))$ | L: $j(x) = O(h(x))$ |

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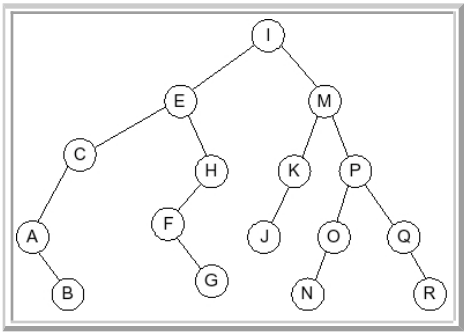
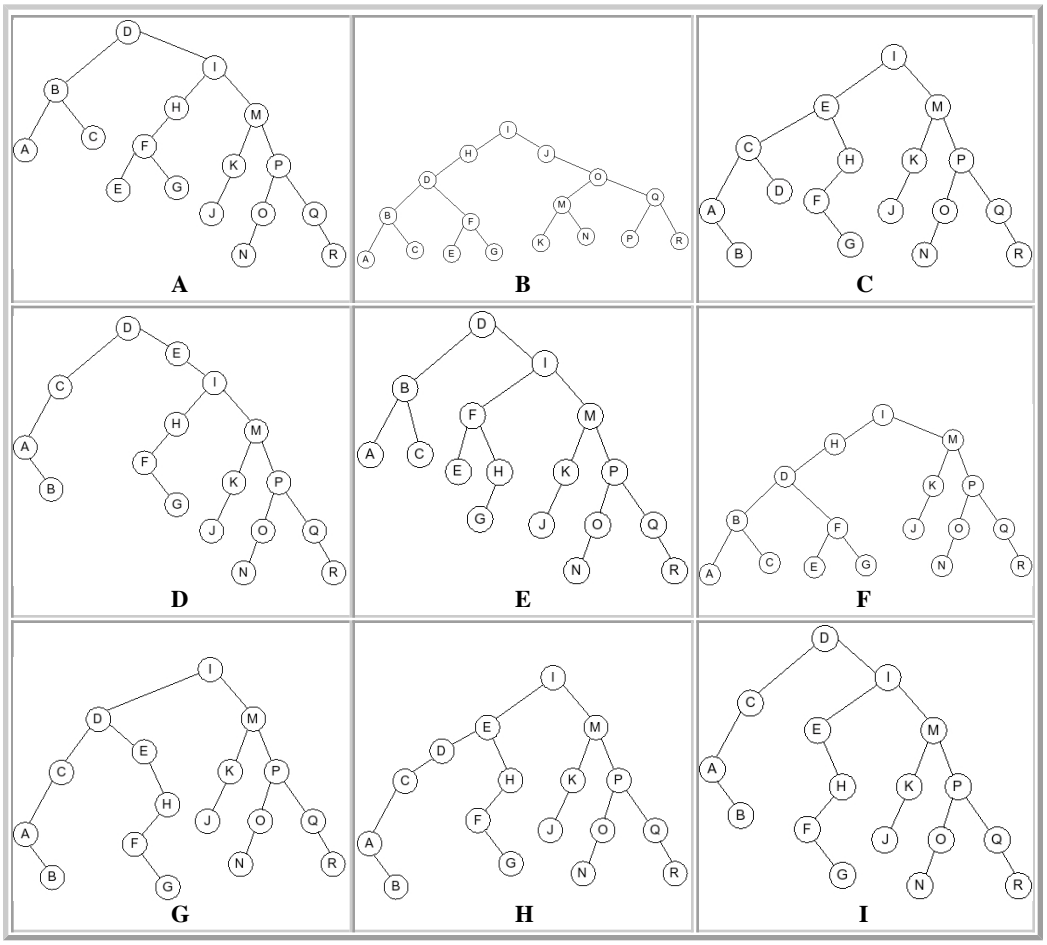
# Question 4

Given the following splay tree:

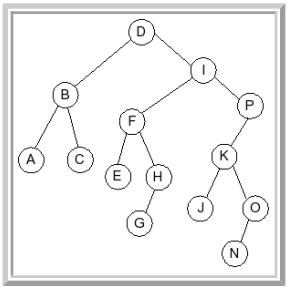



Which of the following is the tree that results when **D** is inserted into the splay tree:

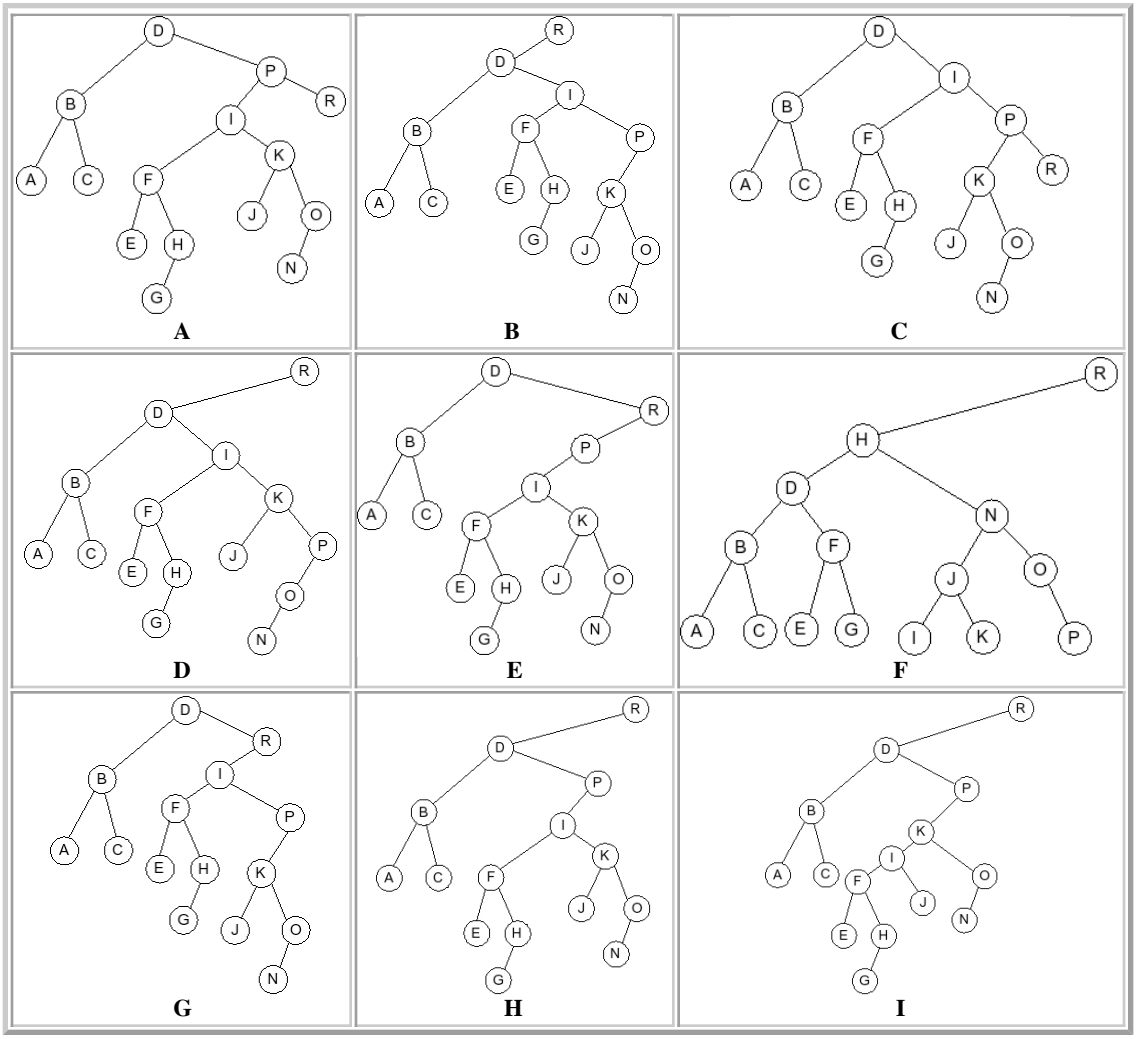


# Question 5

Given the following splay tree:

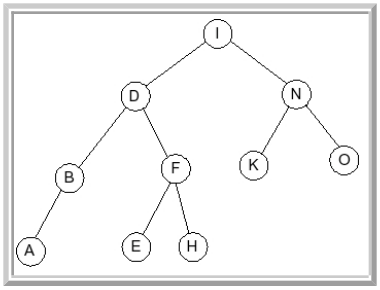



Which of the following is the tree that results when **R** is inserted into the splay tree:

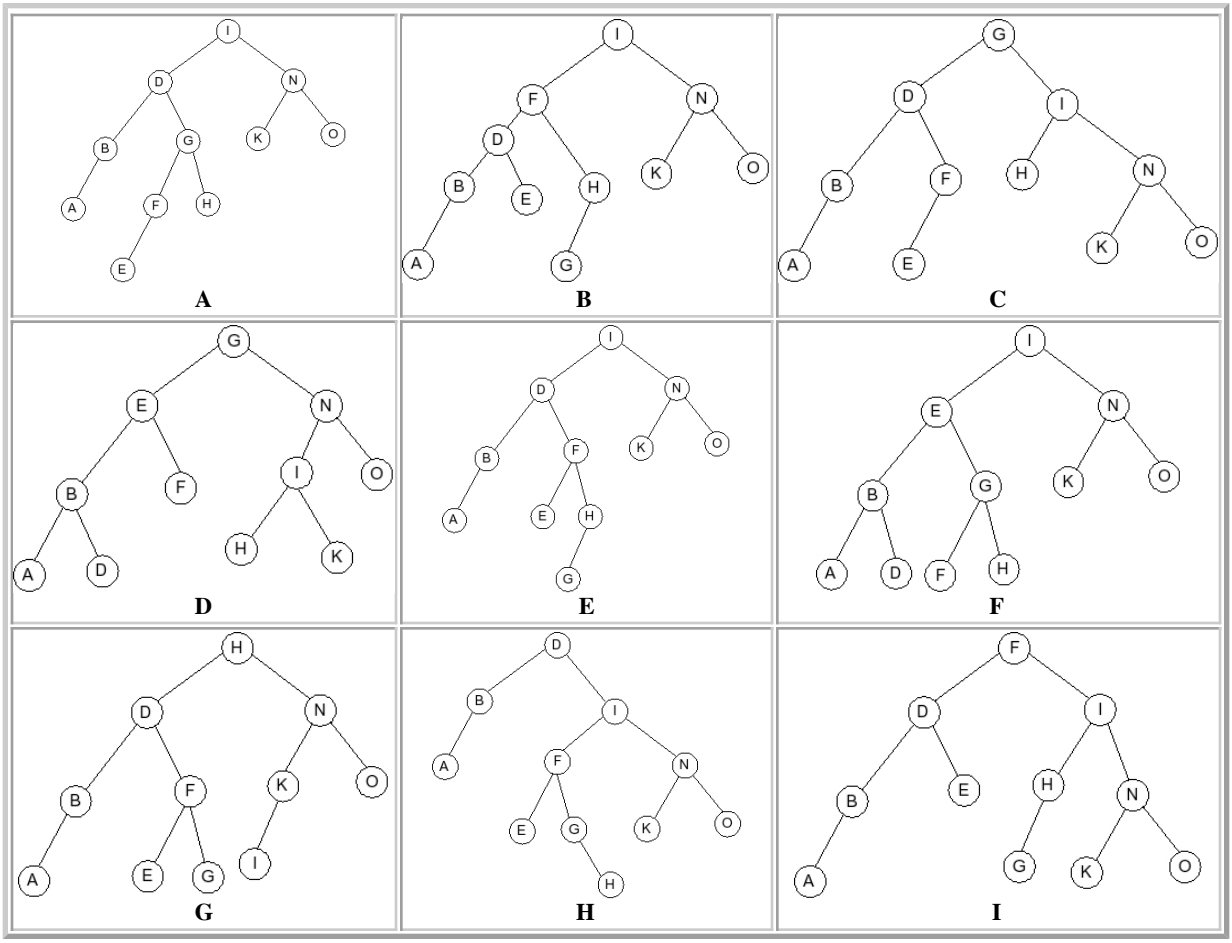


# Question 6

Given the following AVL tree:




Which of the following is the tree that results when **G** is inserted into the AVL tree:



# Question 7

Recall the header file for Disjoint Sets, below left.

```
typedef struct {
  int *links;
  int *sizes;
  int *ranks;
  int maxindex;
  int nsets;
} DisjointSet;

extern DisjointSet *new_disjoint_set(int maxindex);
extern void free_disjoint_set(DisjointSet *dj);
extern void disjoint_makeset(DisjointSet *dj, int index);
extern int disjoint_union(DisjointSet *dj, int s1, int s2);
extern int disjoint_find(DisjointSet *dj, int index);
```

maxindex = 10
nsets = 5

| | links | ranks | sizes |
|---|---|---|---|
| 0 | 4 | 2 | 2 |
| 1 | -1 | 1 | 1 |
| 2 | 0 | 1 | 1 |
| 3 | 7 | 1 | 1 |
| 4 | -1 | 3 | 4 |
| 5 | -1 | 1 | 1 |
| 6 | 4 | 1 | 1 |
| 7 | -1 | 2 | 2 |
| 8 | -1 | 2 | 2 |
| 9 | 8 | 1 | 1 |

Suppose we have a **DisjointSet** struct whose state is depicted above right, and we have a pointer to it in the variable **dj**. Answer the following questions:

- **Part A:** is **disjoint_find(dj, 0)** equal to **disjoint_find(dj, 1)**?
- **Part B:** is **disjoint_find(dj, 0)** equal to **disjoint_find(dj, 2)**?
- **Part C:** is **disjoint_find(dj, 2)** equal to **disjoint_find(dj, 4)**?
- **Part D:** Draw the state of the struct when **disjoint_union(dj, 4, 7)** is called. Draw everything (**links, sizes, ranks, maxindex** and **nsets**). Assume "union by ranks" is used.

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# Question 8

Write a program that takes two command line arguments, **a** and **b**, and prints out all strings that have **a** A's and **b** B's.

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# Question 9

Suppose we have the following **typedef** for a tree node:

```
typedef struct node {
  char *key;
  int nchildren;
  struct node **children;
} Node;
```

The variable **nchildren** is the number of children that a node has, and **children** is an array of pointers to the children. Write a procedure **tree_size(Node *n)**, which returns the number of nodes in the tree rooted at node **n**.