CSE 5311 Name ________________________________

Spring 2003

Test 1

Closed Book Questions

Multiple Choice - WRITE your answer to the LEFT of each problem. 4 points each.

1. The reason for marking nodes in a Fibonacci heap is:
   A. to allow computing the value of the potential function.
   B. to assure that the structure is a Fibonacci heap rather than a binomial heap.
   C. to improve the performance of CONSOLIDATE.
   D. to indicate nodes that have lost a child since becoming a child themselves.
2. Which of the following statements is true?
   A. A binary search tree may be assigned legal AVL tree balance factors if and only if it can be legally colored as a red-black tree.
   B. If a binary search tree may be assigned legal AVL tree balance factors, then it can be legally colored as a red-black tree.
   C. If a binary search tree can be legally colored as a red-black tree, then it may be assigned legal AVL tree balance factors.
   D. No binary search tree can be both assigned legal AVL tree balance factors and be legally colored as a red-black tree.
3. Which property does not hold for binomial heaps?
   A. DECREASE-KEY takes O(1) time.
   B. MINIMUM takes O(lg n) time.
   C. Performing n INSERT operations into an empty heap will take O(n) time.
   D. The number of trees is based on the binary representation of the number of stored items.
4. Which algorithm uses Union-Find trees?
   A. Dijkstra's
   B. Kruskal's
   C. Prim's
   D. The MST technique based on Warshall's algorithm.
5. Assuming that $|E| > |V|$, the time for Prim's algorithm using a Fibonacci heap is:
   A. $O(|E|)$
   B. $O(|E| \log |E|)$
   C. $O(|E| \log |V|)$
   D. $O(|V| \log |V| + |E|)$
6. Brent's rehash technique is used to improve the successful search performance of
   A. (separate) chaining
   B. double hashing
   C. linear probing
   D. optimal hashing
7. The perfect hashing method discussed in class may be viewed as improving which technique?
   A. (separate) chaining
   B. double hashing
   C. linear probing
   D. optimal hashing
8. Which of the following properties would not hold for the potential function for a data structure?
   A. Changes in potential are used in computing the amortized cost of an operation.
   B. The potential can become indefinitely large, even though the number of items stored is fixed.
   C. The potential is never negative.
   D. The potential is not stored by an implementation.
9. Which of the following is not true regarding self-adjusting lists?
   A. The count method records the number of requests for each item and approximates the optimal fixed ordering.
   B. The move-to-front method always brings the requested item to the beginning of the list.
   C. The OPT method is efficient and is a good substitute for the move-to-front method.
   D. The transpose method exchanges the requested item with the item before it unless the requested item is already at the beginning of the list.
10. The master method is most closely related to this analysis technique.
    A. Divide-and-conquer
    B. Hiring problem
    C. Recursion-tree
    D. Substitution

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11. Suppose a gambling game involves a sequence of rolls from a standard six-sided die. A player wins $1 when the value rolled is the same as the previous roll. If a sequence has 601 rolls, what is the expected amount paid out? (5 points)
12. Suppose a gambling game involves a sequence of rolls from a standard six-sided die. A player wins $1 when the value rolled is larger than the previous roll. If a sequence has 601 rolls, what is the expected amount paid out? (5 points)

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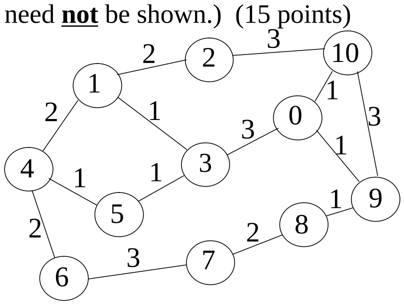
1. Use the master method to derive an asymptotic bound on $T(n) = T(n/2) + n^2$. (10 points)
2. a. Suppose that the root of a tree in a binomial heap has 4 children. What is the minimum number of nodes that may appear in the tree? (3 points)

   b. Suppose that the rightmost path of a leftist heap has 4 nodes. What is the minimum number of nodes that may appear in the heap? (5 points)

   c. Suppose that the root of a tree in a Fibonacci heap has 4 children. What is the minimum number of nodes that may appear in the tree? (7 points)
3. Does the following graph have a unique minimum spanning tree? Trace the contents of the disjoint set structure during the execution of the modified Kruskal's algorithm that checks for uniqueness. (Galler-Fischer representation, i.e. parent pointers, need **not** be shown.) (15 points)



4. Consider the following information for constructing an optimal binary search tree.

```
n=6;
q[0]=0.01;
key[1]=10;
p[1]=0.2;
q[1]=0.02;
key[2]=20;
p[2]=0.1;
q[2]=0.03;
key[3]=30;
p[3]=0.2;
q[3]=0.04;
key[4]=40;
p[4]=0.2;
q[4]=0.0;
key[5]=50;
p[5]=0.06;
q[5]=0.04;
key[6]=60;
p[6]=0.07;
q[6]=0.03;
w[0][0]=0.010000
w[0][1]=0.230000
w[0][2]=0.360000
w[0][3]=0.600000
w[0][4]=0.800000
w[0][5]=0.900000
w[0][6]=1.000000
w[1][1]=0.020000
w[1][2]=0.150000
w[1][3]=0.390000
w[1][4]=0.590000
w[1][5]=0.690000
w[1][6]=0.790000
w[2][2]=0.030000
w[2][3]=0.270000
w[2][4]=0.470000
w[2][5]=0.570000
w[2][6]=0.670000
w[3][3]=0.040000
w[3][4]=0.240000
w[3][5]=0.340000
w[3][6]=0.440000
w[4][4]=0.000000
w[4][5]=0.100000
w[4][6]=0.200000
w[5][5]=0.040000
w[5][6]=0.140000
w[6][6]=0.030000
```

```
Building c(0,2) using roots 1 thru 2
Building c(1,3) using roots 2 thru 3
Building c(2,4) using roots 3 thru 4
Building c(3,5) using roots 4 thru 5
Building c(4,6) using roots 5 thru 6
Building c(0,3) using roots 1 thru 3
Building c(1,4) using roots 3 thru 3
Building c(2,5) using roots 3 thru 4
Building c(3,6) using roots 4 thru 6
Building c(0,4) using roots 2 thru 3
Building c(1,5) using roots 3 thru 4
Building c(2,6) using roots 4 thru 4
Building c(0,5) using roots 3 thru 3
Building c(1,6) using roots 3 thru 4
Building c(0,6) using roots ? thru ?
Counts - root trick 29 without root trick 50
Average probe length is ?
trees in parenthesized prefix
c(0,0) cost 0.000000
c(1,1) cost 0.000000
c(2,2) cost 0.000000
c(3,3) cost 0.000000
c(4,4) cost 0.000000
c(5,5) cost 0.000000
c(6,6) cost 0.000000
c(0,1) cost 0.230000 10
c(1,2) cost 0.150000 20
c(2,3) cost 0.270000 30
c(3,4) cost 0.240000 40
c(4,5) cost 0.100000 50
c(5,6) cost 0.140000 60
c(0,2) cost 0.510000 10(,20)
c(1,3) cost 0.540000 30(20,)
c(2,4) cost 0.710000 30(,40)
c(3,5) cost 0.440000 40(,50)
c(4,6) cost 0.300000 60(50,)
c(0,3) cost 1.100000 20(10,30)
c(1,4) cost 0.980000 30(20,40)
c(2,5) cost 0.940000 40(30,50)
c(3,6) cost 0.740000 40(,60(50,))
c(0,4) cost 1.550000 30(10(,20),40)
c(1,5) cost 1.280000 30(20,40(,50))
c(2,6) cost 1.240000 40(30,60(50,))
c(0,5) cost 1.850000 30(10(,20),40(,50))
c(1,6) cost 1.630000 40(30(20,),60(50,))
c(0,6) cost ???????? ?????????????????????
```

Construct the final optimal binary search tree and give its cost. SHOW YOUR WORK. (10 points)

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Test 2
Closed Book Questions
Multiple Choice - WRITE your answer to the LEFT of each problem. 4 points each.

1. The length of the TSP tour found by the triangle inequality technique achieves what minimization ratio?
   A. 0.5
   B. $1 + \in$
   C. 1.5
   D. 2
2. When performing bin packing using the First-Fit Decreasing technique, the total number of items placed in the bins past the optimal bins (1 .. OPT) is bounded by:
   A. $1 + \in$
   B. 2
   C. OPT - 1
   D. OPT
3. Which of the following is NOT required when showing that problem B is NP-complete by a reduction from problem A.
   A. The reduction takes polynomial time.
   B. The reduction has an inverse that takes each instance of problem B to an instance of problem A.
   C. Problem A is NP-complete
   D. The reduction must be consistent for the decision results for each instance of problem A and the corresponding instance of problem B.
4. When <u>combining</u> the left and right parts for the 2-d closest pair algorithm along the vertical dividing line, each left-side point ‘‘near’’ the line has its distance computed to no more than this number of right-side points.
   A. 6
   B. 8
   C. lg n
   D. n/2
5. Radix sort is useful for which of the following:
   A. Constructing a longest common subsequence using O(m+n) space.
   B. Constructing a suffix array.
   C. Constructing a suffix tree.
   D. Constructing the polynomial for Karp-Rabin string search
6. Which of the following is not required before relabeling (‘‘lifting’’) a vertex to a new height?
   A. Any eligible edges for the present height have been saturated.
   B. Both breadth-first searches have been done.
   C. The vertex is not the source or sink.
   D. The vertex is overflowing.
7. Which of the following is not true for the stable marriages technique that yields the man-optimal matching?
   A. Men propose starting with the beginning of their preference lists.
   B. The order of proposals is irrelevant and the same matching will always be obtained.
   C. When a man proposes to a woman and the woman accepts, they must be paired in the final matching.
   D. Women improve their situation by accepting proposals toward the beginning of their preference lists.
8. Among the problems listed, this problem achieves the best approximation ratio:
   A. Edge coloring
   B. Set cover
   C. TSP with the triangle inequality
   D. Vertex cover
9. Articulation points are found by:
   A. 2-d closest pairs
   B. Convex hull
   C. Depth-first search
   D. Strongly connected components
10. On an augmenting path, a critical edge is:
   A. an edge from the source
   B. an edge into the sink
   C. an edge that used to be saturated
   D. an edge with the minimum residual capacity

==

11. Fill in the Z table. 10 points

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
a	c	a	b	a	c	a	c	a	b	a	c	a	b	a	c

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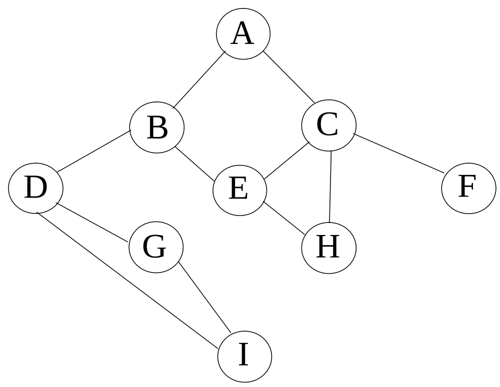
1. Give the suffix array for this string. 15 points

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
a	c	a	b	a	c	a	c	a	b	a	c	a	b	a	c

2. Suppose an application requires finding small vertex covers for many undirected graphs. Even though you are initially concerned about this issue, you proceed with great confidence after learning that every graph will be bipartite. Why? 10 points.
3. Trace the execution of the biconnected components algorithm on the following graph by giving the discovery time and ‘‘back’’ value for each vertex, along with listing the vertices in each biconnected component. 15 points

Vertex:	A	B	C	D	E	F	G	H	I
Discovery:									
Back:									



4. List the remaining operations to complete this instance of network flows by push-relabel. 10 points