CSE 2320 Name ____________________

Test 1

Fall 2011 Last 4 Digits of Mav ID # ______________

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

1. The time to compute the sum of the n elements of an integer array is in:

   A. $\Theta(n)$ B. $\Theta(n \log n)$ C. $\Theta(n^2)$ D. $\Theta(n^3)$

2. Suppose there is a large table with n integers, possibly with repeated values, in ascending order. How much time is needed to determine the number of occurences of a particular value?

   A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(n \log n)$

3. Suppose you have correctly determined some c and n_o to prove $g(n) \in \Omega(f(n))$. Which of the following is not necessarily true?

   A. c may be increased B. c may be decreased C. n_o may be increased D. $f(n) \in O(g(n))$

4. Suppose you are using the substitution method to establish a Θ bound on a recurrence $T(n)$ and you already know that $T(n) \in \Omega(\log n)$ and $T(n) \in O(n^3)$. Which of the following cannot be shown as an improvement?

   A. $T(n) \in O(1)$ B. $T(n) \in O(\log n)$ C. $T(n) \in \Omega(n^2)$ D. $T(n) \in \Omega(n^3)$

5. The function $n \log n + \log n$ is in which set?

   A. $\Omega(n^2)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(n \log n)$

6. Which of the following is not true?

   A. $n^2 \in O(n^3)$ B. $n \log n \in O(n^2)$

   C. $g(n) \in O(f(n)) \Leftrightarrow f(n) \in \Omega(g(n))$ D. $\log n \in O(\log \log n)$

7. Suppose a binary search is to be performed on a table with 28 elements. The maximum number of elements that could be examined (probes) is:

   A. 4 B. 5 C. 6 D. 7

8. Which of the following functions is not in $\Omega(n \log n)$?

   A. n B. $n \lg n$ C. n^2 D. n^3

9. $4^{\lg 7}$ evaluates to which of the following? (Recall that $\lg x = \log_2 x$.)

   A. $\sqrt{7}$ B. 7 C. 30 D. 49

10. What is required when calling `union(i,j)` for maintaining disjoint subsets?

    A. `i` and `j` are in the same subset

    B. `i` and `j` are leaders for different subsets

    C. `i` and `j` are leaders for the same subset

    D. `i` is the ancestor of `j` in one of the trees

Short Answer. 5 points each

1. Explain what it means for a sort to be stable.

2. Suppose $f(n) \in O(g(n))$, $g(n) \in O(h(n))$, and $h(n) \in O(f(n))$. What conclusion may be drawn about the three functions in terms of Θ sets?

3. Perform an asymptotic analysis for the following code segment to determine an appropriate Θ set for the time used.

```
sum=0;
for (i=0; i<n; i=i+2)
  for (j=1; j<n; j=j+j)
    sum=sum + a[i]/a[j];
```

Long Answer

1. Two `int` arrays, `A` and `B`, contain `m` and `n` `int`s each, respectively with `m<=n`. The elements within both of these arrays appear in **ascending order** without duplicates (i.e. each table represents a set).

Give C code for a $\Theta(m+n)$ algorithm to test **set containment** (A $\subseteq$ B) by checking that every value in A appears as a value in B. If set containment holds, your code should `return 1`. If an element of A does not appear in B, your code should `return 0`.

(Details of input/output, allocation, declarations, error checking, comments and style **are unnecessary**.) 15 points

2. Use the recursion-tree method to show that $T(n) = 2T\left(\frac{n}{4}\right) + n^2$ is in $\Theta\left(n^2\right)$. 15 points

3. Use the substitution method to show that $T(n) = 2T\left(\frac{n}{4}\right) + n^2$ is in $\Theta\left(n^2\right)$. 15 points

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Test 2
Fall 2011 Last 4 Digits of Student ID # ____________________

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

1. The purpose of the binary searches used when solving the longest (monotone) increasing subsequence (LIS) problem is:
   A. to assure that the final solution is free of duplicate values
   B. to determine the longest possible increasing subsequence terminated by a particular input value
   C. to search a table that will contain only the LIS elements at termination
   D. to sort the original input
2. The cost function for the optimal matrix multiplication problem is:
   A. $C(i,j) = \min_{i \le k < j} \left\{C(i,k) + C(k,j) + P_{i-1}P_kP_j\right\}$ B. $C(i,j) = \min_{i \le k < j} \left\{C(i,k) + C(k+1,j) + P_iP_kP_j\right\}$
   C. $C(i,j) = \min_{i \le k < j} \left\{C(i,k) + C(k+1,j) + P_{i-1}P_kP_j\right\}$ D. $C(i,j) = \max\left\{C(i,j-1), C(i-1,j)\right\}$ if $x_i \ne y_j$
3. The time to optimally convert an array, with priorities stored at subscripts 1 through n, to a minheap is in:
   A. $\Theta(\log n)$ B. $\Theta(n)$ C. $\Theta(n \log n)$ D. $\Theta\left(n^2\right)$
4. Which of the following is not a property of HEAPSORT for sorting keys into ascending order?
   A. It uses many `fixUp`s.
   B. The heap loses one element after each round.
   C. It is not stable.
   D. A maxheap is used.
5. Which statement is correct regarding the unweighted and weighted activity scheduling problems?
   A. Both require dynamic programming
   B. Both are easily solved using a greedy technique
   C. Unweighted is solved using a greedy technique, weighted is solved by dynamic programming
   D. Weighted is solved using a greedy technique, unweighted is solved by dynamic programming
6. Memoization is associated with which technique?
   A. top-down dynamic programming
   B. `fixDown`
   C. greedy methods
   D. bottom-up dynamic programming
7. Suppose the input to HEAPSORT is always a table of n zeroes and ones. The worst-case time will be:
   A. $\Theta(\log n)$ B. $\Theta(n)$ C. $\Theta(n \log n)$ D. $\Theta\left(n^2\right)$
8. Which of the following is solved heuristically by a greedy method?
   A. Fractional knapsack
   B. Huffman code
   C. Unweighted interval scheduling
   D. 0/1 knapsack
9. When solving the activity scheduling problem (unweighted interval scheduling), the intervals are processed in the following order.
   A. Ascending order of finish time
   B. Ascending order of start time
   C. Descending order of interval length
   D. Descending order of finish time
10. What is minimized in the dynamic programming solution to the subset sum problem?

A. S_j

B. m

C. The number of input values used to sum to each $C(i)$

D. The index stored for each $C(i)$

Long Answer

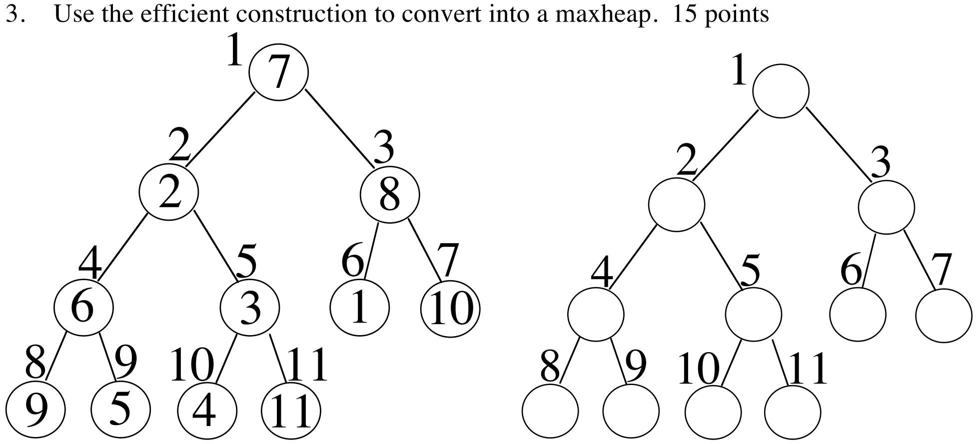
1. Give a Huffman code tree for the following symbols and probabilities. Besides the tree, be sure to compute the expected bits per symbol. 15 points

A	0.25
B	0.28
C	0.12
D	0.12
E	0.15
F	0.07
G	0.01

2. Complete the following example of the efficient dynamic programming technique for finding a Longest Increasing Subsequence (monotone). Circle the inputs that are in the final LIS. (15 points)

	1	2	3	4	5	6	7	8	9	10	11	12
	10	20	30	40	15	25	35	45	17	27	37	47
C	1	2	3	4								
j	0	1	2	3								
1	10/1											
2	20/2											
3	30/3											
4	40/4											
5												
6												
7												
8												

3. Use the efficient construction to convert into a maxheap. 15 points



4. Complete the following example of the efficient dynamic programming technique for finding a longest common subsequence. Be sure to provide the backtrace for your LCS using arrows in the matrix. 15 points

```
0 1 1 0 1 0
1 0 0 1 0 1
```

		1	0	0	1	0	1
	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1
1	0	1	1	1	2	2	2
1	0						

0 0

1 0

0 0

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Test 3

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

1. If POP is implemented as return stack[--SP], then PUSH of element X is implemented as:
   A. stack[SP++] = X B. stack[SP--] = X C. stack[++SP] = X D. return stack[SP++]
2. Which binary tree traversal corresponds to the following recursive code?

```
void traverse(noderef x)
{
if (x==null)
  return;
traverse(x.left);
traverse(x.right);
// process x here
}
```

   A. inorder B. postorder C. preorder D. search for key x
3. What is the worst-case time to perform MINIMUM(*L*) for an ordered, doubly-linked list with *n* nodes?
   A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n)$ D. $\Theta(n \log n)$
4. Given a pointer to a node, the worst-case time to delete the node from a singly-linked list with *n* nodes in ascending order is:
   A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n \log n)$ D. $\Theta(n)$
5. Recently, we considered an abstraction supporting the operations *allocate*, *allocateAny*, and *freeup* which was implemented in constant time. Which of the following was not a feature of the implementation?
   A. a recycling list
   B. a circular, doubly-linked list
   C. a header
   D. arrays
6. The most accurate description of the time to perform a deletion in an unbalanced binary search tree with *n* keys and height *h* is:
   A. $O(1)$ B. $O(\log h)$ C. $O(h)$ D. $O(\log n)$
7. Which of the following would not be used in implementing rat-in-a-maze in a depth-first fashion?
   A. Circular queue B. Recursion C. Stack D. 2-d array
8. In a binary search tree, which element does not have a successor?
   A. any one of the leaves B. the maximum C. the minimum D. the root
9. For which of the following sorts does the decision tree model not apply?
   A. Insertion B. LSD Radix Sort C. MERGE-SORT D. QUICKSORT
10. The expected number of comparisons for finding the *k*th largest of *n* keys using PARTITION is in which asymptotic set?
    A. $\Theta(\log n)$ B. $\Theta(n)$ C. $\Theta(n \log n)$ D. $\Theta(n^2)$

Long Answer

1. Twenty positive integers in the range 0 . . . 999,999,999 are to be sorted by LSD radix sort. Compare the performance for using radix 0 . . . 999 and radix 0 . . . 9. Show your work. (15 points)
2. Show the result after PARTITION manipulates the following subarray. Be sure to circle which version of PARTITION you applied. (15 points)
   8 2 5 7 4 1 9 0 6 3
   Version: 1 2/Sedgewick
3. Problems similar to the one below have appeared frequently on past CSE 2320 exams.
   (A is the answer.)
   Suppose that only numbers in 1 . . . 1000 appear as keys in a binary search tree. While searching for 500, which of the following sequences of keys could not be examined?
   A. 10, 200, 300, 100, 500
   B. 100, 1000, 200, 900, 300, 800, 400, 700, 500
   C. 200, 300, 400, 700, 600, 500

D. 600, 100, 550, 540, 500

Write a short C code segment to check such sequences in linear time. The sequence is already stored in an `int` array `seq` with `n` entries. If the key sequence is valid for a downward path from the root, then print "`valid`". Otherwise, print "`illegal`". Note that an input sequence will not have duplicate values. Declarations, `includes`, `mallocs`, etc. need not be provided! (15 points)

4. Explain how singly-linked lists may be used to implement the stack and queue abstractions. Diagrams, examples, code, or pseudo-code may be used in your answer. (15 points)

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Test 4

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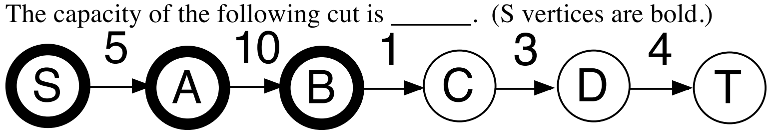
Multiple Choice. Write the letter of your answer to the LEFT of each problem. 2 points each

1. Suppose a depth-first search on a directed graph yields a path of tree edges from vertex X to vertex Y and a path of tree edges from vertex X to Z. If there is also an edge from Y to Z, then its type will be:
   A. Back B. Cross C. Forward D. Tree
2. The worst-case time for depth-first search is:
   A. θ(V lg E) B. θ(E lg V) C. θ(V lg V) D. θ(V + E)
3. Suppose a depth-first search on a directed graph yields a path of tree edges from vertex X to vertex Y. If there is also an edge from Y to X, then its type will be:
   A. Back B. Cross C. Forward D. Tree
4. During a breadth-first search, the status of a white vertex is:
   A. It has been completely processed.
   B. It is in the FIFO queue.
   C. It is in the priority queue.
   D. It is undiscovered.
5. The cycle property for minimum spanning trees may be used to find an MST by:
   A. Growing the MST by repeatedly including a maximum weight edge from some vertex in the tree to some vertex that has not yet been placed in the tree.
   B. Growing the MST by repeatedly including a minimum weight edge from some vertex in the tree to some vertex that has not yet been placed in the tree.
   C. Remove the maximum weight in any cycle until only a tree of edges remains.
   D. Remove the minimum weight in any cycle until only a tree of edges remains.
6. The capacity of any cut is:
   A. An upper bound on the maximum flow.
   B. The same as the capacity of all other cuts.
   C. A lower bound on the maximum flow.
   D. The same as the maximum attainable flow.
7. The capacity of the following cut is ______. (S vertices are bold.)

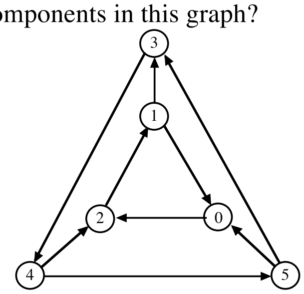


   A. 1 B. 10 C. 15 D. 23
8. Prim's algorithm, when implemented with a heap, is most suitable for:
   A. Finding the minimum spanning tree of a dense graph.
   B. Finding the minimum spanning tree of a sparse graph.
   C. Finding the shortest paths from a designated source vertex in a dense graph.
   D. Finding the shortest paths from a designated source vertex in a sparse graph.
9. Before searching for a minimum cut in a network, it is useful to do the following:
   A. Find one augmenting path.
   B. Determine the type of each edge using depth-first search.
   C. Find and record augmenting paths until none remains.
   D. Perform a breadth-first search on the input network.
10. Suppose the compressed adjacency list representation is used for a directed graph with *n* vertices and *m* edges. The number of entries in the two tables are:
   A. *n* for both
   B. *m* for both
   C. *n* and *m*
   D. *n* + 1 and *m*
11. When using two breadth-first searches to find the diameter of a tree, the purpose of the first search is to find:
   A. all vertices that could be an end of a diameter.

B. both ends of a diameter.
C. one end of a diameter.
D. the number of edges in the diameter.

12. The expected number of probes for an unsuccessful search in hashing by chaining with α as the load factor is:
A. $\frac{\alpha}{2}$ B. $\frac{2}{3}\alpha$ C. α D. 2α

13. What is the number of strongly connected components in this graph?



A. 1 B. 2 C. 3 D. 4

14. Dijkstra's algorithm may be viewed as being a generalization of which technique?
A. BFS
B. DFS
C. Minimum spanning trees
D. Maximum flow

15. The number of potential probe sequences when using double hashing with a table with *m* entries (*m* is prime) is:
A. $O(\log m)$ B. m C. $m(m-1)$ D. $m!$

16. Suppose a maximum bipartite matching with *k* edges is found using maximum flow. Which of the following does not hold?
A. There will be *k* + 1 breadth-first searches.
B. All residual network capacities are zero or one.
C. Every augmenting path uses three edges.
D. The capacity of the minimum cut is *k*.

Problems 17 and 18 refer to the following hash table whose keys are stored by double hashing using $h_1(key) = key \% 13$ and $h_2(key) = 1 + (key \% 12)$.

0	1	2	3	4	5	6	7	8	9	10	11	12
			120	186	187	162		122	110			194

17. 303 would be inserted into which slot of the given table?
A. 0 B. 2 C. 3 D. 7

18. 263 would be inserted into which slot of the given table?
A. 0 B. 2 C. 3 D. 7

Problems 19 and 20 refer to the following hash table whose keys are stored by linear probing using $h(key) = key \% 13$.

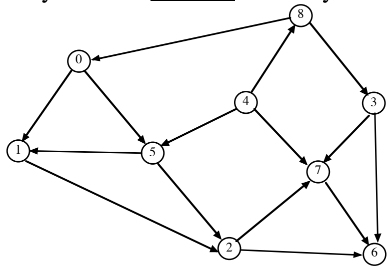
0	1	2	3	4	5	6	7	8	9	10	11	12
			94		122	110	20	86	87	62		

19. 136 would be inserted into which slot of the given table?
A. 0 B. 4 C. 6 D. 11

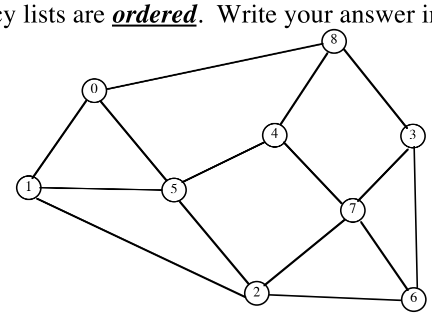
20. 143 would be inserted into which slot of the given table?
A. 0 B. 1 C. 2 D. 11

Long Answer

1. Demonstrate, for the graph below, the algorithm that uses ***depth-first search*** to determine a topological ordering. Assume that the adjacency lists are ***ordered***. Show your work. 10 points



2. Perform depth-first search on the following graph, including start/finish times and edge types (T=tree, B=back, C=cross, F=forward.) Assume that the adjacency lists are ***ordered***. Write your answer in the tables below. 10 points

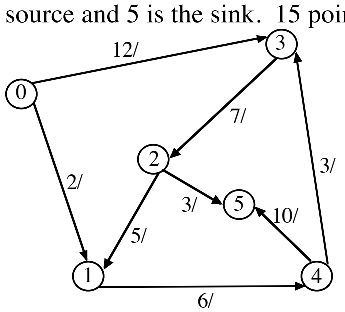


Vertex	Start	Finish	Edge	Type	Edge	Type
0	1	____	0 1	____	3 8	____
1	____	____	0 5	____	4 5	____
2	____	____	0 8	____	4 7	____
3	____	____	1 2	____	4 8	____
4	____	____	1 5	____	6 7	____
5	____	____	2 5	____		
6	____	____	2 6	____		
7	____	____	2 7	____		
8	____	____	3 6	____		
			3 7	____		

3. Demonstrate the Floyd-Warshall algorithm, ***with successors***, for the following input adjacency matrix. (`999` represents infinity) The paths indicated in the final matrix must have ***at least one*** edge. You ***are not*** required to show the intermediate matrices. 15 points.

	0	1	2	3	4
0	999	999	3	999	4
1	999	999	11	12	4
2	8	6	999	5	999
3	15	999	20	999	999
4	999	999	5	999	999

4. Give augmenting paths for determining a maximum flow, along with a minimum cut for the following network. 0 is the source and 5 is the sink. 15 points.



S vertices: 0
T vertices: 5
Augmenting Paths and Contribution to Flow:

5. Insert 9 into the given red-black tree. 10 points