CSE 2320 Name _____
Test 1
Fall 2005 Last 4 Digits of Student ID # _____

Multiple Choice. Write your answer to the LEFT of each problem. 3 points each

1. Which of the following functions is not in $\Omega\left(n^2\right)$?
   A. n
   B. n^2
   C. $n^2 \lg n$
   D. n^3
2. BUILD-MAX-HEAP is based on applying MAX-HEAPIFY in the following fashion:
   A. In ascending slot number order, for each slot that is a parent.
   B. In descending slot number order, for each slot that is a parent.
   C. $\frac{n}{2}$ times, each time from the root of the heap.
   D. n - 1 times, each time from the root of the heap.
3. Suppose that a binary search is to be performed on a table with 40 elements. The maximum number of elements that could be examined (probes) is:
   A. 4 B. 5 C. 6 D. 7
4. Suppose $f\left(x\right)$ is a monotonically increasing function. Which of the following approximates the summation?
   A. $\int_{m}^{n} f(x)dx \le \sum_{k=m}^{n} f(k) \le \int_{m}^{n} f(x)dx$
   B. $\int_{m-1}^{n} f(x)dx \le \sum_{k=m}^{n} f(k) \le \int_{m}^{n+1} f(x)dx$
   C. $\int_{m-1}^{n-1} f(x)dx \le \sum_{k=m}^{n} f(k) \le \int_{m+1}^{n+1} f(x)dx$
   D. $\int_{m}^{n+1} f(x)dx \le \sum_{k=m}^{n} f(k) \le \int_{m-1}^{n} f(x)dx$
5. Which recurrence describes the worst-case time used by MERGE-SORT?
   A. $T\left(n\right) = T\left(\frac{n}{2}\right) + n$
   B. $T\left(n\right) = 2T\left(\frac{n}{2}\right) + n$
   C. $T\left(n\right) = T\left(n-1\right) + n$
   D. $T\left(n\right) = T\left(\frac{n}{2}\right) + 1$
6. Which of the following sorts does not have a straightforward statement of its worst case?
   A. Insertion
   B. MERGE-SORT
   C. QUICKSORT
   D. Shellsort
7. What is the value of H_3?
   A. lg 4
   B. $\frac{1}{4}$
   C. $\frac{11}{6}$
   D. 3
8. f(n) = n lg n is in all of the following sets, except
   A. $\Omega(\lg n)$
   B. $\Theta(\log(n!))$
   C. $O(1/n)$
   D. $O(n^2)$

9. What is the value of $\sum_{k=0}^{\infty} \left(\frac{2}{3}\right)^k$?
   A. $\frac{1}{3}$
   B. $\frac{2}{3}$
   C. $\frac{3}{2}$
   D. 3
10. Which of the following is not an application of a minheap?
   A. Choosing the pivots for QUICKSORT.
   B. Constructing sorted subfiles for external mergesort.
   C. Controlling multiway merges for external mergesort.
   D. Selecting the third smallest number from a set of one million numbers.
11. The worst-case time to merge two ordered sequences, one with *m* elements and the other with *n* elements, to construct another ordered sequence is:
   A. $\Theta(\min(m,n))$
   B. $\Theta(m+n)$
   C. $\Theta(mn)$
   D. $\Theta(mn(\lg m + \lg n))$
12. Suppose that you have correctly determined some c and n_o to prove that $f(n) \in O(g(n))$. Which of the following is not necessarily true?
   A. c may be decreased
   B. c may be increased
   C. n_o may be increased
   D. $g(n) \in \Omega(f(n))$
13. Suppose you are using the substitution method to establish a Θ bound on a recurrence $T(n)$ and that you already know that $T(n) \in \Omega(\lg n)$ and $T(n) \in O(n^2)$. Which of the following cannot be shown as an improvement?
   A. $T(n) \in O(\lg n)$
   B. $T(n) \in O(n)$
   C. $T(n) \in \Omega(n^2)$
   D. $T(n) \in \Omega(n^3)$
14. Which of the following is not true regarding a maxheap with 1000 elements?
   A. Subscript 1 will store the maximum priority.
   B. The parent for the node with subscript 500 is stored at subscript 250.
   C. The left child for the node with subscript 200 is stored at subscript 400.
   D. The right child for the node with subscript 405 is stored at subscript 911.
15. The expected time for insertion sort for *n* keys is in which set? (All *n*! input permutations are equally likely.)
   A. $\Theta(\log n)$
   B. $\Theta(n)$
   C. $\Theta(n \log n)$
   D. $\Theta(n^2)$

Long Answer

1. Complete the function by writing the code to replace each `???` on the line to its right. 10 points

```
int binSearchLast(a,n,key)

int *a;
```

```
int n,key;

{

// Finds index of last slot with a key <= a given key

// WARNING - Returns -1 if key<a[0].  06/16/05

  int low,high,mid;

  low=0;

  high=???;                    __________

  while (low???high)           __________

  {

    mid=???;                          __________

    if (a[mid]???key)          __________

      low=mid+1;

    else

      high=mid-1;

  }

  return ???;                         __________

}
```

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

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

4. Demonstrate how several executions of PARTITION may be used to determine the second largest element of the following array. The last element of a subarray will be used as the pivot. 15 points

9 3 1 8 5 6 2 7 4

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Test 2

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Multiple Choice. Write the letter of your answer to the LEFT of each problem. 3 points each

1. Why is it common for a circular queue implementation to waste one table element?
   A. To avoid confusing an empty table with a full table
   B. To have a place to store the tail and head values
   C. To make sure the queue always has at least one element in use
   D. To perform some loops faster
2. Given a pointer to a node, the worst-case time to delete the node from a doubly-linked list with *n* nodes in ascending order is:
   A. $\Theta(1)$
   B. $\Theta(\log n)$
   C. $\Theta(n \log n)$
   D. $\Theta(n)$
3. The worst-case time to find the maximum key in a singly-linked list with *n* nodes in ascending order is:
   A. $\Theta(1)$
   B. $\Theta(\log n)$
   C. $\Theta(n \log n)$

D. $\Theta(n)$

4. How should the successor of a node with a right child in an unbalanced binary search tree be found?
   A. Examine the ancestors of the node
   B. Go left, then proceed to the right
   C. Go right, then proceed to the left
   D. Preorder traversal
5. If POP is implemented as return stack[--SP], then PUSH of element X is implemented as:
   A. return stack[SP++]
   B. stack[SP++] = X
   C. stack[SP--] = X
   D. stack[++SP] = X
6. Using the values *never-used* (-1) and *recycled* (-2) is part of which data structure?
   A. binary search trees
   B. chaining
   C. open addressing
   D. ordered linked lists
7. The queue for breadth-first rat-in-a-maze stores
   A. all maze positions that have walls
   B. maze positions that must be in the final path
   C. maze positions that have been reached
   D. the current path being explored
8. In the example of recycling the elements of a list in O(1) time, which situation holds?
   A. Both lists are circular
   B. Both lists are not circular
   C. The garbage list is not circular, the list to be recycled is circular
   D. The list to be recycled is not circular, the garbage list is circular
9. The two mandatory pointers in a node for a rooted tree with linked siblings are:
   A. First child and right sibling
   B. Left child and right child
   C. Left child and parent
   D. Left sibling and right sibling
10. In which situation will a sentinel be inappropriate?
    A. Binary search for a key in an ordered table, to simplify and speed-up code
    B. Search for a key in an unordered table, to simplify and speed-up code
    C. Search for a key in an unordered linked list, to simplify and speed-up code
    D. Red-black tree, to simplify code
11. Which of the following will not be true regarding the decision tree for HEAP-SORT for sorting n input values?
    A. Every path from the root to a leaf will have $\mathrm{O}(n \log n)$ decisions.
    B. The height of the tree is $\Omega(n \log n)$.
    C. There will be a path from the root to a leaf with $\Omega\left(n^2\right)$ decisions.
    D. There will be $n!$ leaves.
12. Which sort treats keys as several digits and uses a counting sort for each position?
    A. counting
    B. insertion
    C. merge
    D. radix
13. Which of the following sorts is stable?
    A. heapsort
    B. insertion
    C. quick
    D. shell
14. 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. $\mathrm{O}(1)$
    B. $\mathrm{O}(\log n)$
    C. $\mathrm{O}(h)$

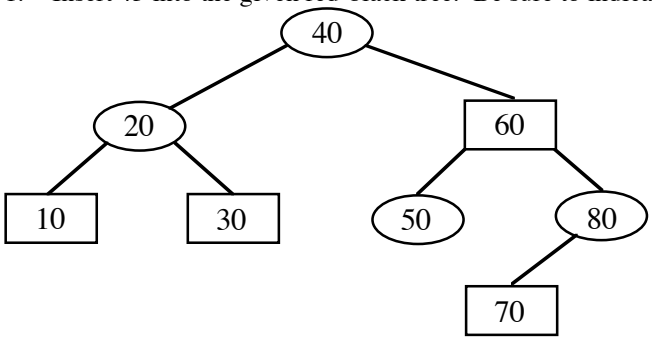
D. $O(n)$

15. Suppose that a sequence of *n* keys will be inserted into an initially-empty instance of the following data structures. Which of the following will not take $\Theta(n^2)$ worst-case time for the entire sequence?

A. linear probing hash table
B. ordered linked list
C. red-black tree
D. unbalanced binary search tree

Long Answer

1. Insert 45 into the given red-black tree. Be sure to indicate the cases that you used. (10 points)

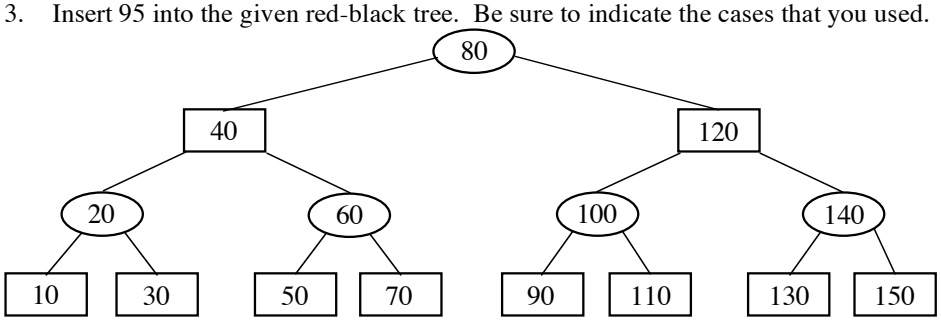


2. Consider the following hash table whose keys were stored by linear probing using h(key, i) = (key + i) % 11.

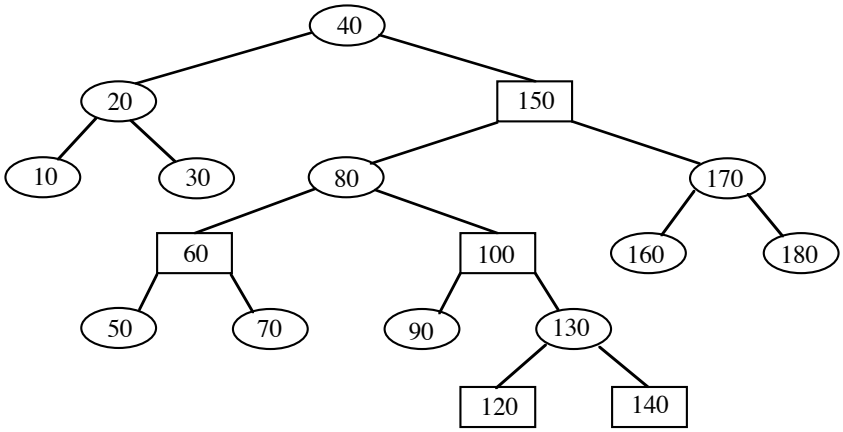
```
0  22
1
2
3
4  59
5  4
6  15
7  28
8
9  31
10  10
```

a. Suppose 135 is to be stored (using linear probing). Which slot will be used? (5 points)
b. Suppose 142 is to be stored (using linear probing) after 135 has been stored. Which slot will be used? (5 points)

3. Insert 95 into the given red-black tree. Be sure to indicate the cases that you used. (10 points)



4. Insert 110 into the given red-black tree. Be sure to indicate the cases that you used. (10 points)



5. Consider the following hash table whose keys were stored by double hashing using $h_1(key) = key \% 11$ and $h_2(key) = 1 + (key \% 10)$.

```
0  22
1
2
3  17
4  4
5  15
6  28
7
8
9
10 10
```

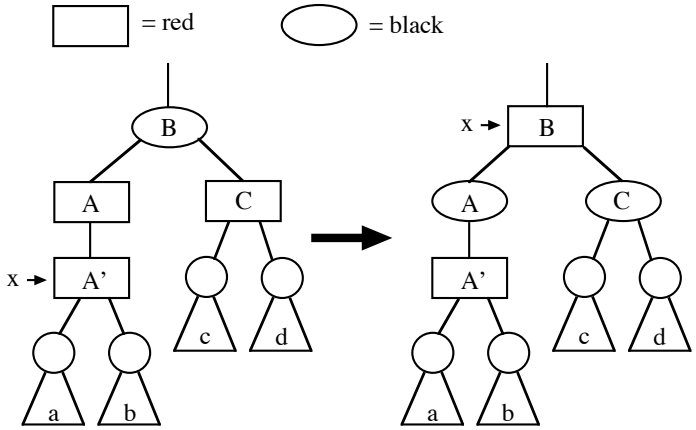
a. Suppose 142 is to be inserted (using double hashing). Which slot will be used? (5 points)

b. Suppose 130 is to be inserted (using double hashing) after 142 has been stored. Which slot will be used? (5 points)

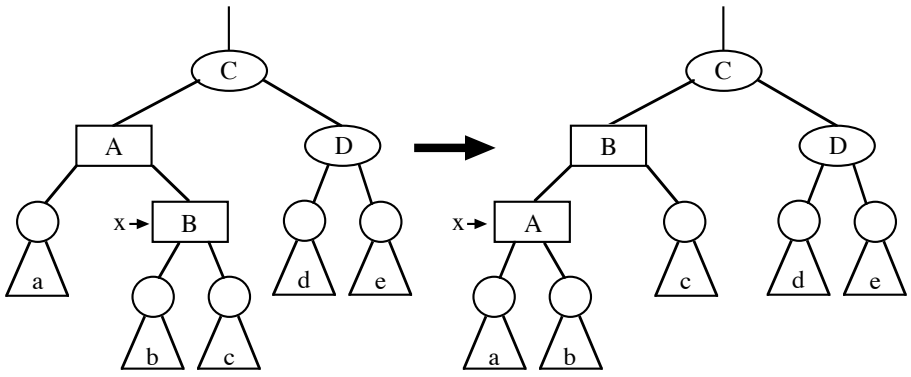
6. Give the prefix and postfix versions of the infix expression (1 + 2) * (3 - 4) / 5. (5 points)

This page may be detached from the exam and recycled.

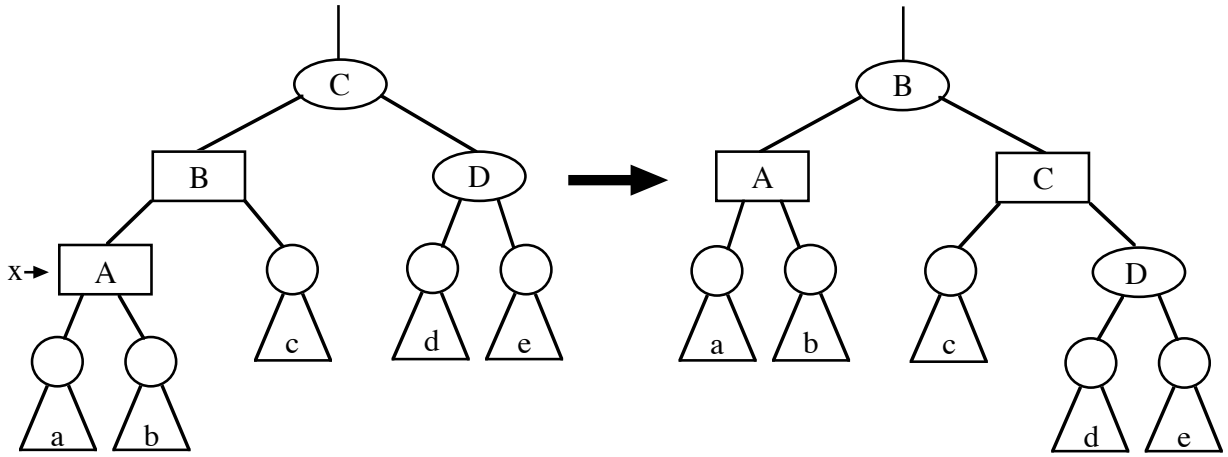
Case 1:



Case 2:



Case 3:



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Test 3

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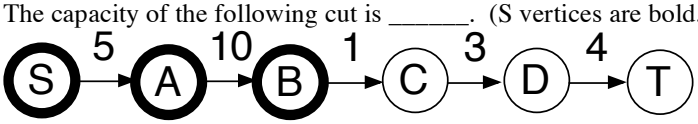
Multiple Choice. Write the letter of your answer to the LEFT of each problem. 3 points each

1. The capacity of the following cut is _____. (S vertices are bold.)



A. 1 B. 10 C. 15 D. 23

2. Which of the following is **not** based on a matrix representation?
   A. Dijkstra's algorithm
   B. Floyd-Warshall algorithm
   C. Longest common subsequence construction
   D. Warshall's algorithm
3. 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*
4. Which of the following is a longest common subsequence for 0 1 0 2 1 2 and 0 0 1 1 2 2?
   A. 0 0 1 1 B. 0 0 1 1 2 C. 0 0 1 2 D. 0 1 2 0
5. When a graph is dense, the best way to find a shortest path between every pair of vertices is:
   A. Dijkstra's algorithm using heap
   B. Dijkstra's algorithm using T-table
   C. Floyd-Warshall algorithm
   D. Warshall's algorithm
6. The worst-case time for Prim's algorithm implemented with a T-heap is:
   A. $\theta(V + E)$ B. $\theta(E \lg V)$ C. $\theta(V \lg V)$ D. $\theta(V \lg E)$
7. During depth-first search on a directed graph, a cycle is indicated by which edge type?
   A. Back B. Cross C. Forward D. Tree
8. Suppose that there is exactly one path from vertex 5 to vertex 10 in a directed graph: $5 \rightarrow 7 \rightarrow 3 \rightarrow 8 \rightarrow 10$. During the scan of which column will Warshall's algorithm record the presence of this path?
   A. 2 B. 5 C. 7 D. 8
9. When finding the strongly connected components, the number of components is indicated by:
   A. The number of back edges found during the first depth-first search.
   B. The number of cross edges found during the second depth-first search.
   C. The number of restarts for the first depth-first search.
   D. The number of restarts for the second depth-first search.
10. The Edmonds-Karp variant is important because:
    A. It solves the bipartite matching problem.
    B. It solves the network flow problem in polynomial time.
    C. It solves the network flow problem using critical edges.
    D. It solves the network flow problem without using augmenting paths.

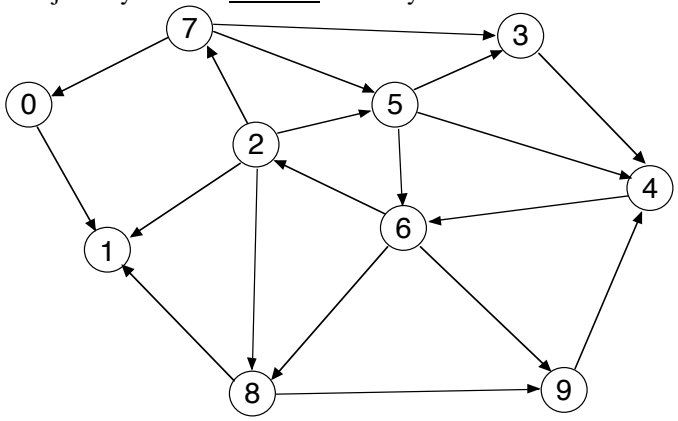
11. Suppose that a depth-first search on a directed graph yields a path of tree edges from vertex X to vertex Y. If there is also an edge from Y to X, then its type will be:
    A. Back B. Cross C. Forward D. Tree
12. The number of HEAP-EXTRACT-MINs to build a Huffman code tree for n symbols is:
    A. $\theta(\log n)$ B. $n - 1$ C. n D. $2n - 2$
13. Suppose that a directed graph is to be stored and then queries for the presence of various edges will be submitted. Which of the following worst-case time bounds for testing whether one edge is present is **incorrect**? (Vertices are conveniently labeled by numbers 0, 1, . . ., $V - 1$.)
    A. Adjacency lists (ordered): $\Theta(\log V)$
    B. Adjacency lists (unordered): $\Theta(V)$
    C. Adjacency matrix: $\Theta(1)$
    D. Compressed adjacency lists (ordered): $\Theta(\log V)$
14. Suppose that an instance of bipartite matching has 10 vertices in the left column, 15 vertices in the right column, and 30 edges. The number of edges in the corresponding instance of network flow is:
    A. 25
    B. 30
    C. 55
    D. 150
15. Suppose that an instance of the fractional knapsack problem has more than one optimal solution by using the greedy approach. Each solution is distinguished by the amount of each available item that is placed in the knapsack. Which of the following must hold?
    A. All available items have the same $$$/lb ratio.
    B. Each available item has a different $$$/lb ratio.
    C. The amount chosen of the last item placed in the knapsack must be a fraction of the available amount, i.e. some of that item will be left out of the knapsack.
    D. The last two items chosen for the knapsack have the same $$$/lb ratio.

Long Answer

1. Solve the following instance of the activity scheduling problem using the greedy method. 5 points.

Activity	Start	Finish
A	1	4
B	3	8
C	7	12
D	11	16
E	5	10
F	6	9
G	2	15
H	13	14

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



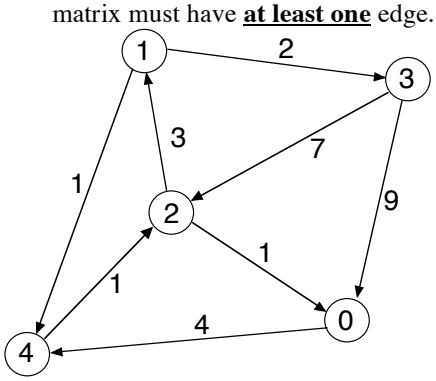
Vertex	Start	Finish
0	1	____
1	____	____
2	____	____
3	____	____

Edge	Type
0 1	____
2 1	____
2 5	____
2 7	____

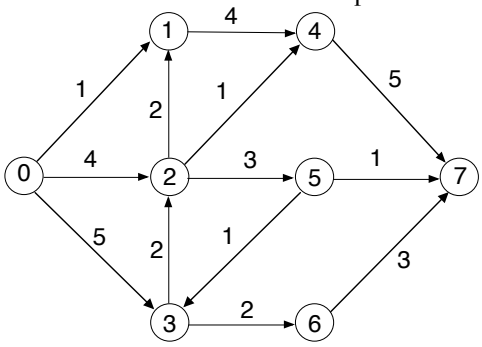
Edge	Type
6 2	____
6 8	____
6 9	____
7 0	____

4	____	____	2 8	____		7 3	____	
5	____	____	3 4	____		7 5	____	
6	____	____	4 6	____		8 1	____	
7	____	____	5 3	____		8 9	____	
8	____	____	5 4	____		9 4	____	
9	____	____	5 6	____				

3. Demonstrate the Floyd-Warshall algorithm, **with successors**, for the following graph. The paths indicated in the final matrix must have **at least one** edge. You are not required to show the intermediate matrices. 10 points.



4. Give augmenting paths for determining a maximum flow and give a minimum cut for the following network. 0 is the source and 7 is the sink. 10 points.



S vertices: 0
T vertices: 7
Augmenting Paths and Contribution to Flow:

5. Complete the following instance of the optimal matrix multiplication ordering problem, including the tree showing the optimal ordering. 10 points

p[0]=5 p[1]=4 p[2]=6 p[3]=2 p[4]=5 p[5]=6

	1		2		3		4		5	
1	0	0	120	1	88	1	138	3	**???**	**?**
2	-------		0	0	48	2	88	3	156	3
3	-------		-------		0	0	60	3	132	3
4	-------		-------		-------		0	0	60	4
5	-------		-------		-------		-------		0	0

6. What are the entries in the T-table (for Prim's algorithm) before **and** after moving the next vertex and edge into the minimum spanning tree? DO NOT COMPLETE THE ENTIRE MST!!! Edges already in the MST are the thick ones. 10 points.