CSE 2320
Test 1
Spring 2019

____
Your name as it appears on your UTA ID Card

Multiple Choice:

1. Write the letter or value of your answer on the line (_____) to the LEFT of each problem.
2. CIRCLED ANSWERS DO NOT COUNT.
3. 2 points each

1. The time to run the code below is in:

```
for (i=n; i>=0; i--)
  for (j=0; j<n*n; j+=2)
    sum+=i*j;
```

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

2. When did we use $\sum_{k=0}^{t} x^k \leq \sum_{k=0}^{\infty} x^k = \lim_{k \to \infty} \frac{x^k - 1}{x - 1} = \frac{1}{1-x}$?

_____ A. To define H_n
B. For a recursion tree that has the same contribution for each level
C. For a recursion tree that has decreasing contributions by each level going away from the root
D. For a recursion tree that has increasing contributions by each level going away from the root

3. Which of the following is true?

_____ A. $n^3 \in \Omega(n^2)$ B. $n \log n \in \Omega(n^2)$
C. $g(n) \in O(f(n)) \Leftrightarrow f(n) \in O(g(n))$ D. $3^n \in O(2^n)$

4. Bottom-up maxheap construction is based on applying `maxHeapify` 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 subscript 1.
D. In descending slot number order, for each slot that is a leaf.

5. Which function is in both $\Omega(2^n)$ and $O(3^n)$, but is not in $\Theta(2^n)$ and $\Theta(3^n)$?

_____ A. $2^n + n^2$ B. $3^n - n^2$ C. 2.5^n D. $\ln n$

6. $f(n) = \lg n$ is in all of the following sets, except

_____ A. $O(\log n)$ B. $O(\log(n!))$ C. $\Omega(n)$ D. $O(n^2)$

7. Suppose the input to heapsort is always a table of n ones. The worst-case time will be:

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

8. The time to run the code below is in:

```
sum=1;
for (i=1; i<n*n; i=3*i)
  sum++;
```

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

9. The number of calls to `heapExtractMin` to build a Huffman code tree for n symbols is:

_____ A. $\Theta(\log n)$ B. n - 1 C. n D. $2n$ - 2

10. Suppose you are using the substitution method to establish a Θ bound on a recurrence $T(n)$ and you already know $T(n) \in \Omega(n)$ 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. $T(n) \in \Omega(n \lg n)$

11. Suppose a binary search is to be performed on a table with 62 elements. The maximum number of elements that could be examined (probes) is:

_____

12. Heapsort may be viewed as being a faster version of which sort?

_____ A. selection B. `qsort`
C. insertion D. mergesort

13. 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. $\Theta(n^2)$

14. Which of the following is a longest common subsequence for 0 1 2 0 1 2 and 0 0 1 1 2 2?

_____ A. 0 0 2 2 B. 0 1 2 2 C. 0 0 1 1 D. 0 0 1 1 2

15. The time to extract the LCS (for sequences of lengths m and n) after filling in the dynamic programming matrix is in:

_____ A. $\Theta(n)$ B. $\Theta(m + n)$ C. $\Theta(n \log n)$ D. $\Theta(mn)$

16. What is the value of $\sum_{k=0}^{\infty} \left(\frac{1}{3}\right)^k$?

_____

17. The time to multiply two $n \times n$ matrices is:

_____ A. $\Theta(n)$ B. $\Theta(\max(m,n,p))$ C. $\Theta(n^3)$ D. $\Theta(mnp)$

18. The goal of the optimal matrix multiplication problem is to:

_____ A. Minimize the number of C(i,j) instances evaluated.
B. Minimize the number of matrix multiplications.
C. Minimize the number of scalar multiplications.
D. Minimize the number of scalar additions.

19. Which of the following is solved heuristically by a greedy method?

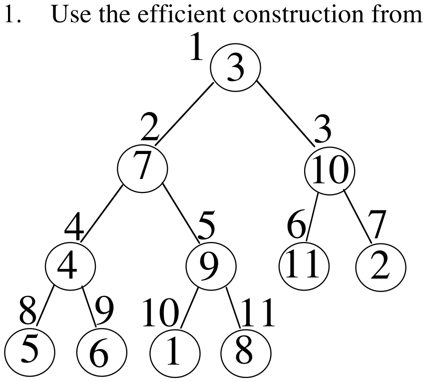
_____ A. Fractional knapsack B. Huffman coding
C. Unweighted interval scheduling D. 0/1 knapsack

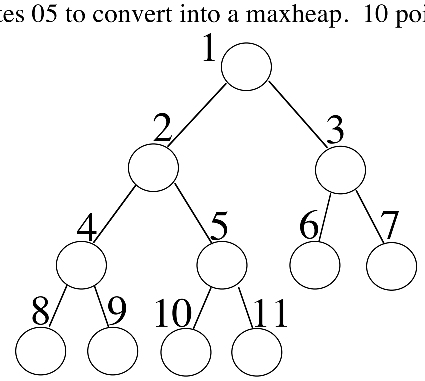
20. Suppose a Huffman code tree is constructed for an alphabet with eight symbols where each symbol has a probability of 0.125 of occuring. What is the expected bits per symbol?

_____

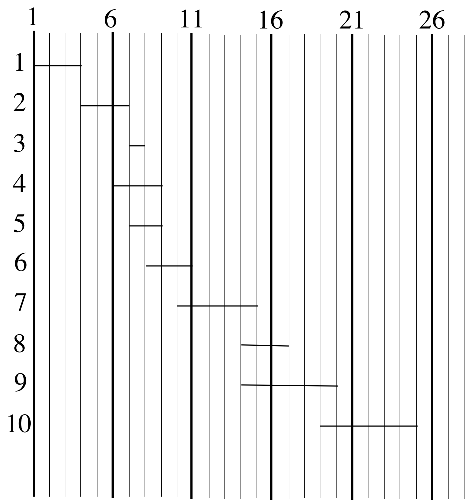
Long Answer

1. Use the efficient construction from Notes 05 to convert into a maxheap. 10 points





2. Use dynamic programming to solve the following instance of weighted interval scheduling. Be sure to clearly indicate the intervals in your solution and the sum achieved. 10 points



v_i	p_i	$m(i)$
1	0	
5	1	
3	2	
8	1	
1	2	
2	3	
3	5	
1	6	
4	6	
1	8	

3. Use the greedy method for unweighted interval scheduling for the set of intervals in the previous problem. You may give your solution as the numbers of the chosen intervals. 5 points
4. 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**.) 10 points
5. Give the tree corresponding to the following instance of optimal matrix multiplication. 5 points

```
6
4 3 2 5 4 7 5
```

	1		2		3		4		5		6	
1	0	0	24	1	64	2	96	2	176	2	230	2
2	-------		0	0	30	2	64	2	138	2	196	2
3	-------		-------		0	0	40	3	96	4	166	5
4	-------		-------		-------		0	0	140	4	240	4
5	-------		-------		-------		-------		0	0	140	5
6	-------		-------		-------		-------		-------		0	0

6. Use the recursion-tree method to show that $T(n)=3T\left(\frac{n}{3}\right)+n$ is in $\Theta(n\log n)$. 10 points
7. Use the substitution method to show that $T(n)=3T\left(\frac{n}{3}\right)+n$ is in $O(n\log n)$. (You do not need to show that $T(n)$ is in $\Omega(n\log n)$.) 10 points

CSE 2320 Name ________________________________
Test 2
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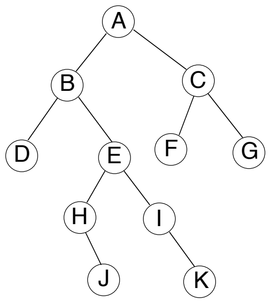
Multiple Choice:
1. Write the letter of your answer on the line (_____) to the LEFT of each problem.
2. CIRCLED ANSWERS DO NOT COUNT.
3. 2 points each

1. The minimum number of rotations while inserting a key into a red-black tree is:
_____ A. 0 B. 1 C. 2 D. 3
2. Suppose the tree below is a binary search tree whose keys and subtree sizes are not shown. Which node will contain the key with rank 5? (Write the node's letter on the line.)



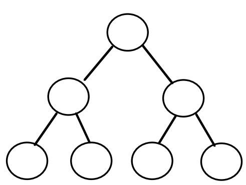
_____
3. Memoization is associated with which technique?
_____ A. bottom-up dynamic programming B. top-down QUICKSORT
C. bottom-up MERGESORT D. top-down dynamic programming

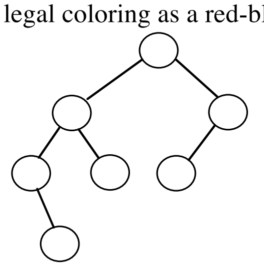
4. Circular linked lists are occasionally useful because
_____ A. some operations may be done in constant time.
B. they are an alternative to binary search trees.
C. they are useful for implementing circular queues.
D. they avoid mallocs.

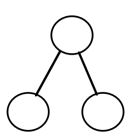
5. Given a pointer to a node, the worst-case time to delete the node from an unsorted, doubly-linked list with n nodes is:
_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n \log n)$ D. $\Theta(n)$

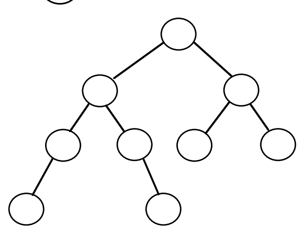
6. Suppose that only numbers in 1 . . . 1000 appear as keys in a binary search tree. While searching for 500, which of the following sequences of keys could not be examined?
_____ A. 200, 700, 600, 300, 400, 500
B. 300, 400, 900, 800, 500
C. 700, 200, 600, 550, 500
D. 100, 1000, 200, 800, 300, 900, 500

7. Which of the following binary trees has *exactly* one legal coloring as a red-black tree?

_____ A. 

B. 

C. 

D. 

8. Which phase of counting sort clears the count table?
_____ A. second B. first C. fourth D. third

9. How will a circular queue implementation test for an empty queue?
_____ A. return count==0 B. return tail==head
C. return head==0 D. return tail==0

10. Which of the following will not be true regarding the decision tree for QUICKSORT for sorting n input values?
_____ A. There will be $n!$ leaves.
B. Every path from the root to a leaf will have $O(n \log n)$ decisions.
C. There will be a path from the root to a leaf with $\Omega(n^2)$ decisions.
D. The height of the tree is $\Omega(n \log n)$.

11. Suppose a node x in an unbalanced binary search tree has two children, each storing one key. What is the first step to delete x?
_____ A. Find the predecessor of x B. Inorder traversal
C. Rotate x so it becomes a leaf D. Find the successor of x

12. If POP is implemented as return stack[SP--], then the test for an empty stack is implemented as:

_____ A. return stack[SP++] B. return SP==(-1) C. return SP==0 D. return stack.empty

13. Suppose a (singly) linked list is used to implement a queue. Which of the following is true?
_____ A. The head points to the first element and the tail points to the last element.
B. One node is always wasted.
C. The tail points to the first element and the head points to the last element.
D. Like a circular queue, the maximum number of items is determined at initialization.

14. Which binary tree traversal corresponds to the following recursive code?

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

_____ A. inorder B. postorder C. preorder D. search for key `x`

15. Suppose a binary search tree includes each subtree's size at the subtree's root. How should the rank for the key stored at the tree's root be computed?
_____ A. Add 1 to the subtree size stored at the root.
B. Add 1 to the subtree size for the subtree to the left of the root.
C. Subtract 1 from the subtree size for the subtree to the right of the root.
D. Count nodes while doing an inorder traversal.

16. Assuming the input has been sorted, Huffman coding may use:
_____ A. queues B. dynamic programming C. linked lists D. stacks

17. In the example of recycling the elements of a list in O(1) time, which element becomes the first element of the garbage list?
_____ A. The first element of the circular list
B. The second element of the circular list
C. The last element of the circular list
D. The second element of the original garbage list

18. What is minimized in the dynamic programming solution to the subset sum problem?
_____ A. The number of input values used to sum to each $C(i)$ B. S_j
C. The index stored for each $C(i)$ D. m

19. The worst-case number of comparisons for finding the kth largest of n keys using PARTITION is in which asymptotic set?
_____ A. $\Theta(\log n)$ B. $\Theta(n)$ C. $\Theta(n \log n)$ D. $\Theta(n^2)$

20. Given a pointer to a node, the worst-case time to insert the node into an unsorted, doubly-linked list with n nodes is:
_____ A. $\Theta(1)$ B. $\Theta(\log n)$ C. $\Theta(n \log n)$ D. $\Theta(n)$

Long Answer

1. Use dynamic programming to solve the following instance of the ***monotonicallly*** longest increasing subsequence. Be sure to provide the table for the binary searches, along with the tables of lengths and predecessors for backtracing. (10 points, no points for solving by inspection)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5	10	15	20	25	7	10	15	22	25	5	10	22	26	27

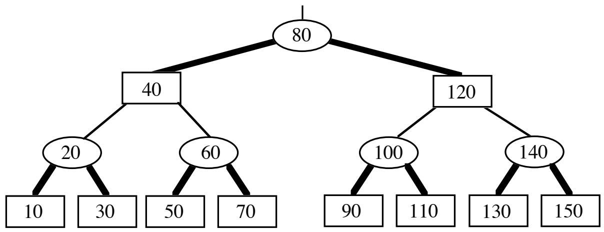
2. Use the dynamic programming solution for subset sums to determine a subset that sums to 13. (10 points, no points for solving by inspection)

i	0	1	2	3	4	5
S_i	0	1	2	3	4	8

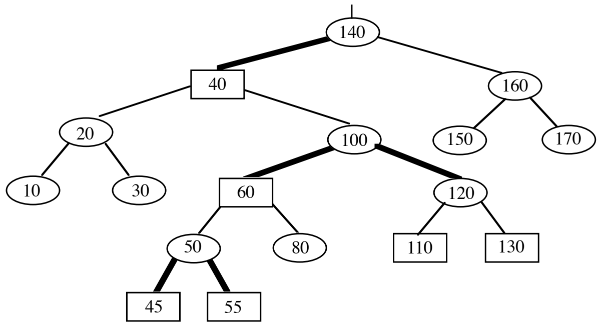
3. Show the result after PARTITION (Version 1) manipulates the following subarray. Recall that both pointers start at the left end of the subarray. (10 points)

9 0 7 3 8 2 5 1 4 6

4. Insert 132 into the given red-black tree. Be sure to indicate the cases that you used. (10 points)



5. Insert 52 into the given red-black tree. Be sure to indicate the cases that you used. 10 points.



6. A billion integers in the range 0 . . . 999,999 are to be sorted by LSD radix sort. How much faster will this be done if radix 0 . . . 999 is used rather than decimal (0 . . . 9) radix? Show your work. (10 points)

CSE 2320 Name ________________________________

Test 3 Your name as it appears on your UTA ID Card

Spring 2019

Multiple Choice:

1. Write the letter or value for your answer on the line (_____) to the LEFT of each problem.
2. CIRCLED ANSWERS DO NOT COUNT.
3. 2 points each

1. Suppose the compressed adjacency list representation is used for a directed graph with *n* vertices and *m* edges. The value stored at the last entry of the tailTab is:

_____

2. For a double hash table with $\alpha = 0.75$ (without deletions), the upper bound on the expected number of probes for unsuccessful search is:

_____

3. Path compression is part of which disjoint subset implementation?

_____ A. Implementation 1 B. Implementation 2
C. Implementation 3 D. All three implementations

4. 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 Z to X, then its type will be:

_____ A. Back B. Cross C. Forward D. Tree

5. Which edge is chosen in a phase of Kruskal's algorithm?

_____ A. The unprocessed edge (x, y) of smallest weight such that `find(x)==find(y)`
B. An edge of maximum-weight in a cycle (to be excluded)
C. An edge that is on a shortest path from the source
D. The unprocessed edge (x, y) of smallest weight such that `find(x)!=find(y)`

6. The capacity of any cut is:

_____ A. A lower bound on the maximum flow. B. An upper bound on the maximum flow.
C. The same as the capacity of all other cuts. D. The same as the maximum attainable flow.

7. Suppose a directed graph has a path from vertex X to vertex Y, but no path from vertex Y to vertex X. The relationship between the finish times for depth-first search is:

_____ A. finish(X) > finish(Y) B. finish(X) < finish(Y)
C. finish(X) = finish(Y) D. could be either A. or B.

8. Suppose an instance of bipartite matching has 4 vertices in the left column, 8 vertices in the right column, and 17 edges. The number of edges in the corresponding instance of network flow is:

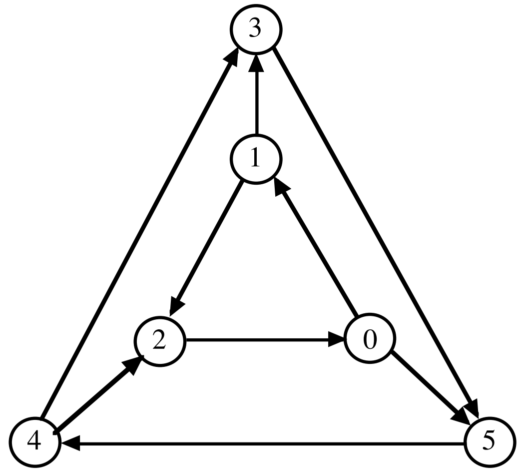
_____

9. The relationship of the net flow across a cut and the amount of flow from the source to the sink is:

_____ A. They are equal.
B. The amount of flow does not exceed the net flow.
C. The net flow does not exceed the amount of flow.

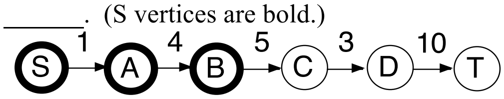
D. There is no relationship.

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



_____

11. The capacity of the following cut is ______. (S vertices are bold.)



_____

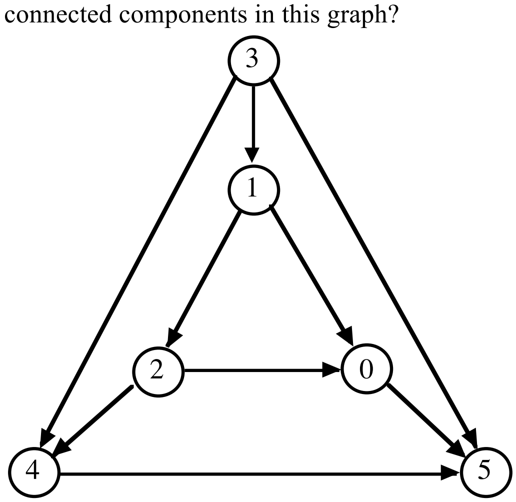
12. A topological ordering of a directed graph may be computed by:

_____ A. Ordering the vertices by descending finish time after DFS
B. Ordering the vertices by ascending discovery time after DFS
C. Ordering the vertices by ascending finish time after DFS
D. Ordering the vertices by descending discovery time after DFS

13. During a breadth-first search, the status of a gray vertex is:

_____ A. It is in the FIFO queue. B. It has been completely processed.
C. It is undiscovered. D. It is in the priority queue.

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



_____

15. The worst-case time for Prim's algorithm implemented with a T-table is:

_____ A. θ(E log V) B. θ(V^2 + E) C. θ(V log E) D. θ(V log V)

16. 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.

17. The worst-case time for Dijkstra's algorithm implemented with a minheap is:

_____ A. θ(V + E) B. θ(E log V) C. θ(V log V) D. θ(V log E)

18. Before searching for a minimum cut in a network, it is useful to do the following:

_____ A. Find one augmenting path.
B. Perform a breadth-first search on the input network.
C. Determine the type of each edge using depth-first search.
D. Find and record augmenting paths until none remains.

19. Which person listed below has not won the Turing Award?

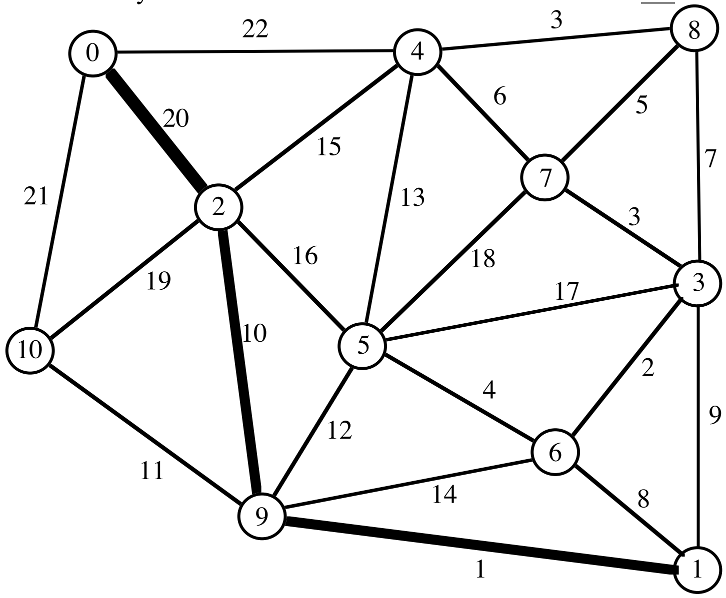
_____ A. Dijkstra B. Goldberg C. Karp D. Tarjan

20. What is the Edmonds-Karp variant?

_____ A. Searching a residual network for an augmenting path of maximum capacity.
B. Using BFS to search a residual network for an augmenting path.
C. Using DFS to search a residual network for an augmenting path.
D. Using the capacity of cuts to bound the amount of flow.

Long Answer

1. What are the entries in the heap (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. Edges currently not in the MST are the narrow ones. You do not need to show the binary tree for the heap ordering. 10 points.

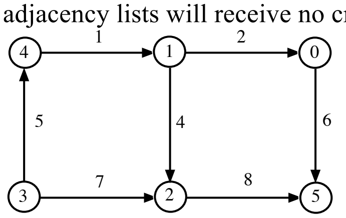


2. Consider the following hash table whose keys were stored by double hashing using $h_1(key) = key \% 11$ and $h_2(key) = 1 + (key \% 10)$. ***Show your work***.

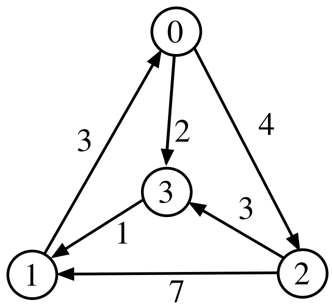
0	220
1	660
2	442
3	333
4	
5	555
6	
7	777
8	882
9	999
10	

a. Suppose 111 is to be inserted (using double hashing). Which slot will be used? (5 points)
b. Suppose 1001 is to be inserted (using double hashing) ***after*** 111 has been stored. Which slot will be used? (5 points)

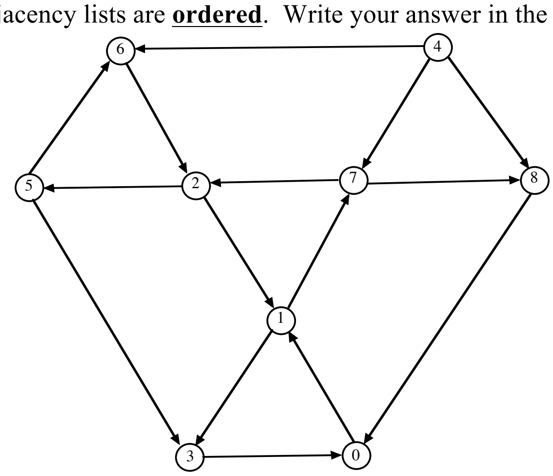
3. Show the ***compressed*** adjacency list representation for this weighted, directed graph. (Answers using conventional adjacency lists will receive no credit.) 10 points.



4. 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.

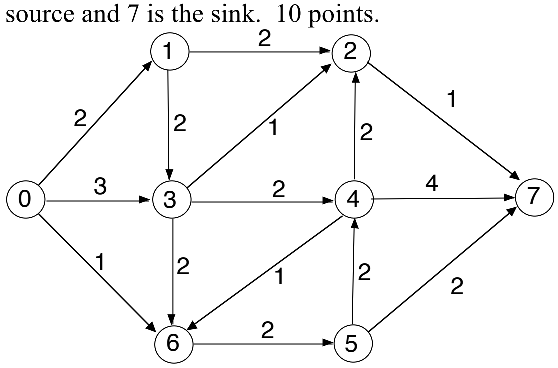


5. Perform depth-first search on the following graph, including start/finish times and edge types (T=tree, B=back, C=cross, F=forward.) Assume that the adjacency lists are **ordered**. Write your answer in the tables below. 10 points



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

6. 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.



Minimum Cut:

S vertices: 0

T vertices: 7

Augmenting Paths and Contribution to Flow: