

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

1. The time to multiply an $m \times n$ matrix and a $n \times p$ matrix is:

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

2. 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

3. Which sort is not stable?

- A. heap B. insertion C. merge D. selection

4. Suppose $H_n = \frac{25}{12}$. What is the value of n ?

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

5. The function $2n + 3n \log n$ is in which set?

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

6. Which of the following facts cannot be proven using one of the limit theorems?

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

7. What is n , the number of elements, for the largest table that can be processed by binary search using no more than 5 probes?

- A. 31 B. 63 C. 64 D. 127

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

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

9. The worst-case time to initially construct a minheap for n keys is in which set?

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

10. Which of the following is true regarding mergesort?

- A. It is difficult to code without recursion
 B. It is difficult to code to ensure stability
 C. It may be coded to operate in a bottom-up fashion
 D. The input must be preprocessed to exploit ordered subarrays or sublists in the input.

11. Suppose that you have correctly determined some c and n_0 to prove $g(n) \in \Omega(f(n))$. Which of the following is not necessarily true?

- A. c may be decreased B. c may be increased C. n_0 may be increased D. $f(n) \in O(g(n))$

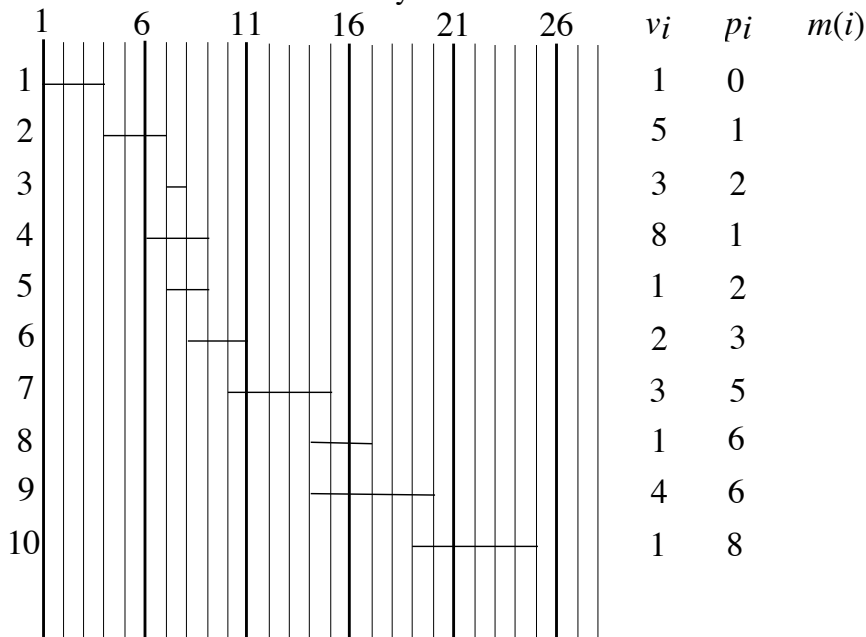
12. Suppose you are using the substitution method to establish a Θ bound on a recurrence $T(n)$ and you already know $T(n) \in \Omega(\lg n)$ and $T(n) \in O(n^2)$. Which of the following cannot be shown as an improvement?

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

13. 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
14. Which situation for operating on a maxheap uses a swim?
 A. decreaseKey
 B. getMax
 C. insert
 D. heapsort
15. Which of the following is a longest common subsequence for 0 1 2 0 1 2 and 0 0 1 2 1 2?
 A. 0 0 1 1 B. 0 1 2 1 2 C. 0 0 1 2 D. 0 1 2 0

Long Answer

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



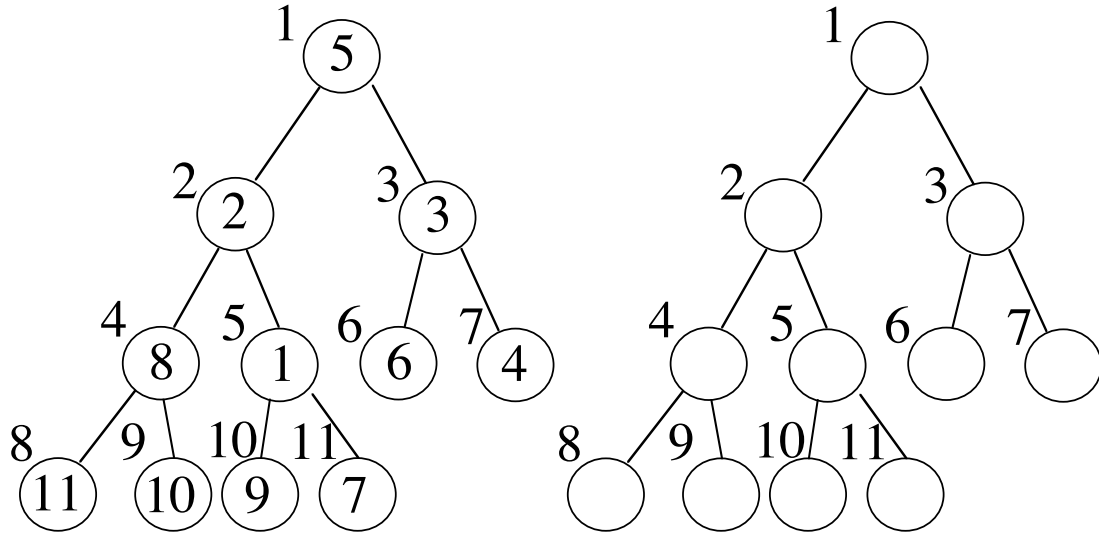
2. Use the greedy method for unweighted interval scheduling for the set of intervals in the previous problem. You may list the numbers of the chosen intervals. 5 points
3. Use the recursion-tree method to show that $T(n) = 2T\left(\frac{n}{2}\right) + n^2$ is in $\Theta(n^2)$. 10 points
4. Use the substitution method to show that $T(n) = 2T\left(\frac{n}{2}\right) + n^2$ is in $\Theta(n^2)$. 10 points
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]=2
 p[2]=2
 p[3]=4
 p[4]=6

1 2 3 4

1	0	0	20	1	56	1	???	?
2	-----		0	0	16	2	64	3
3	-----	-----			0	0	48	3
4	-----	-----	-----				0	0

6. Use the efficient construction to convert into a maxheap. 10 points

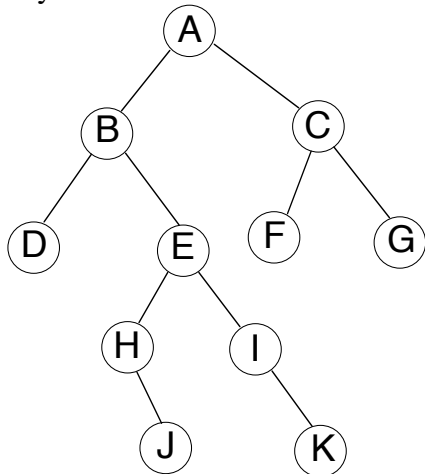


CSE 2320
 Test 2
 Spring 2007

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

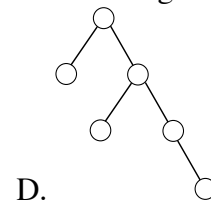
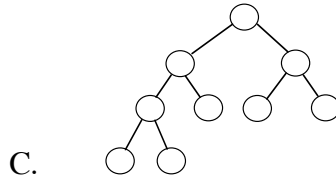
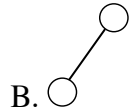
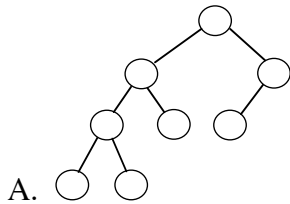
- Why is it common for a circular queue implementation to waste one table element?
 - To avoid confusing an empty table with a full table
 - To have a place to store the tail and head values
 - To make sure the queue always has at least one element in use
 - To perform some loops faster
- Suppose the tree below is a binary search tree whose keys are not shown. Which node will contain the key that is the successor of the key stored at K?



- A. A B. B C. E D. J

- Counting sort is useful for implementing which other sort?

- A. INSERTION-SORT B. LSD radix sort C. MERGE-SORT D. QUICKSORT
- What is the worst-case time to perform $\text{MINIMUM}(L)$ for an unsorted, doubly-linked list with n nodes?
 - $\Theta(1)$
 - $\Theta(\log n)$
 - $\Theta(n)$
 - $\Theta(n \log n)$
 - Which type of linked list will be the most convenient if $\text{LOGICALPREDECESSOR}$ and LOGICALSUCCESSOR operations will be frequent?
 - ordered, doubly-linked
 - ordered, singly-linked
 - unordered, doubly-linked
 - unordered, singly-linked
 - The stack for rat-in-a-maze stores
 - all positions that have walls
 - maze positions that must be in the final path
 - the current path being explored
 - the shortest known path that leads to the cheese
 - The expected number of probes for a successful search in hashing by chaining with α as the load factor is:
 - $\frac{\alpha}{2}$
 - $\frac{2}{3}\alpha$
 - α
 - 2α
 - The most accurate description of the time to perform an insertion in an unbalanced binary search tree with n keys and height h is:
 - $O(1)$
 - $O(\log n)$
 - $O(h)$
 - $O(n)$
 - For which of the following sorts does the decision tree model not apply?
 - Insertion
 - LSD Radix Sort
 - MERGE-SORT
 - QUICKSORT
 - If POP is implemented as $\text{return stack[--SP]}$, then the test for an empty stack is implemented as:
 - $\text{return stack[SP++]}$
 - $\text{return SP} == (-1)$
 - $\text{return SP} == 0$
 - $\text{stack[SP++]} = X$
 - Which of the following binary trees has more than one legal red-black tree coloring?



- In which situation will a sentinel be inappropriate?
 - Binary search for a key in an ordered table, to simplify and speed-up code
 - Search for a key in an unordered table, to simplify and speed-up code
 - Search for a key in an unordered linked list, to simplify and speed-up code
 - Red-black tree, to simplify code
- In the example of recycling the elements of a list in $O(1)$ time, which situation holds?
 - Both lists are not circular
 - Both lists are circular
 - The garbage list is circular, the list to be recycled is not
 - The list to be recycled is circular, the garbage list is not
- Which binary tree traversal corresponds to the following recursive code?

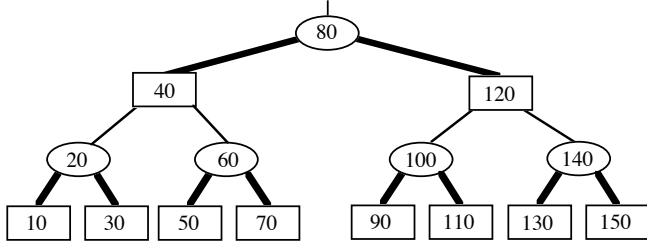

```
void traverse(noderef x)
{
  if (x==null)
    return;
  traverse(x.left);
  traverse(x.right);
  // process x here
}
```

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

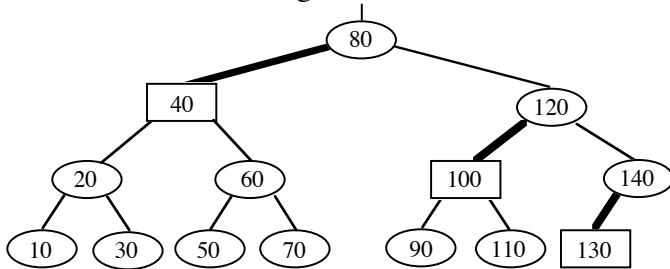
15. Suppose that only numbers in $1 \dots 1000$ appear as keys in a binary search tree. While searching for 500, which of the following sequences of keys could not be examined?
- A. 10, 200, 300, 100, 500
 - B. 100, 1000, 200, 900, 300, 800, 400, 700, 500
 - C. 200, 300, 400, 700, 600, 500
 - D. 600, 100, 550, 540, 500

Long Answer

1. Use a modular hash function to place the listed keys in hash structure with collisions handled by chaining with 5 linked lists. (5 points)
 0 1 2 3 4 5 6 11 12 13 14 15
2. Demonstrate the dynamic programming technique for finding a Longest Increasing Subsequence (monotone) for the following sequence. (10 points)
 10 20 30 40 15 25 35 45 17 27 37 47
3. Show the result after PARTITION manipulates the following subarray. Be sure to indicate which version of PARTITION you applied. (10 points)
 7 0 2 4 3 1 6 9 8 5
4. Give the four phases in a counting sort and their asymptotic worst-case times. (10 points)
5. Insert 55 into the given red-black tree. Be sure to indicate the cases that you used. (10 points)



6. Insert 135 into the given red-black tree. Be sure to indicate the cases that you used. (10 points)



CSE 2320

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Test 3

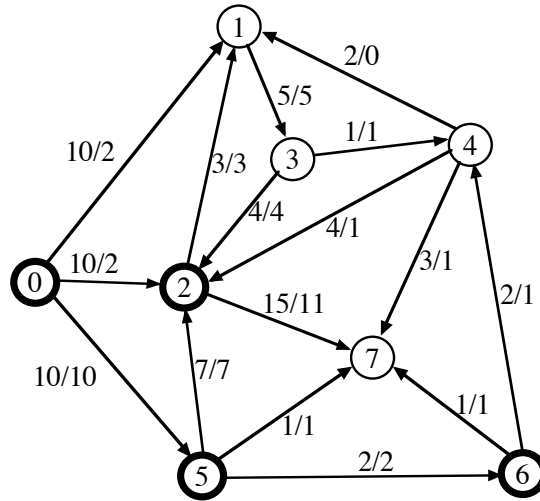
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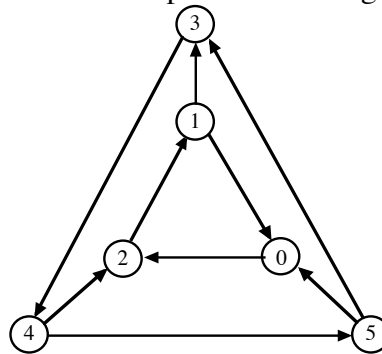
Multiple Choice. Write the letter of your answer to the LEFT of each problem. 2 points each

1. In Dijkstra's algorithm, the final shortest path distance from the source s to a vertex x is known when:
 - A. some vertex y moves from T to S and there is an edge from y to x .
 - B. x has its entry extracted from the heap.
 - C. x has its heap entry changed by a MIN-HEAP-DECREASE-KEY.
 - D. x is read from the input file.

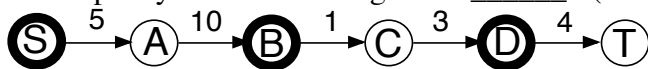
Problems 2, 3, and 4 refer to the following network. 0 is the source. 7 is the sink. Each edge is labeled with capacity/flow.



2. The capacity of the indicated cut (S vertices are bold) is:
 - A. 20
 - B. 30
 - C. 31
 - D. 32
3. The net flow across the given cut is:
 - A. 14
 - B. 16
 - C. 18
 - D. 20
4. Suppose the flow is increased as much as possible using the augmenting path $0 \rightarrow 2 \rightarrow 4 \rightarrow 7$. Which is the critical edge?
 - A. $0 \rightarrow 2$
 - B. $2 \rightarrow 4$
 - C. $4 \rightarrow 7$
 - D. Insufficient information
5. Before searching for a minimum cut in a network, it is useful to do the following:
 - A. Determine the type of each edge using depth-first search.
 - B. Find and record augmenting paths until none remains.
 - C. Find one augmenting path.
 - D. Perform a breadth-first search on the input network.
6. What is the number of strongly connected components in this graph?



- A. 1
 - B. 2
 - C. 3
 - D. 4
7. Which of the following uses a min-heap?
 - A. Breadth-first search
 - B. Depth-first search
 - C. Maximum capacity path
 - D. Prim's algorithm
 8. Compressed adjacency lists have the following disadvantage:
 - A. Testing whether an edge from X to Y is present will take $\theta(V + E)$ worst-case time.
 - B. They are static.
 - C. They can only be used for graphs without weights.
 - D. They require $\theta(V + E)$ space to store.
 9. The capacity of the following cut is _____. (S vertices are bold.)

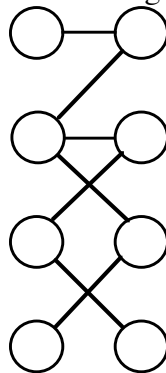


A. 1 B. 10 C. 13 D. 23

10. When a graph is sparse, the best way to find a minimum spanning tree is:
 A. Floyd-Warshall algorithm
 B. Prim's algorithm using heap
 C. Prim's algorithm using T-table
 D. Warshall's algorithm
11. 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.
12. 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.
13. A topological ordering of a directed graph may be computed by:
 A. Ordering the vertices by ascending discovery time after DFS
 B. Ordering the vertices by ascending finish time after DFS
 C. Ordering the vertices by descending discovery time after DFS
 D. Ordering the vertices by descending finish time after DFS
14. Suppose a depth-first search is performed on an undirected graph. There are no cycles if:
 A. no edge is a cross edge or forward edge
 B. both C and D
 C. there are no restarts
 D. there are no back edges
15. Assuming that each key stored in a double hash table with $\alpha = 0.8$ (without deletions), the upper bound on the expected number of probes for unsuccessful search is:
 A. 1.2 B. 2 C. 5 D. 10
16. Suppose an adjacency matrix represents a directed graph with V vertices (numbered $0 \dots V-1$) and an adjacency list representation (with unordered lists) represents a directed graph with the same vertices. How fast can you verify that the two representations are storing the same graph? You are allowed to use additional memory.

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

17. The number of edges in a maximum bipartite matching for the graph below is:



A. 2 B. 3 C. 4 D. 5

18. The number of potential probe sequences when using linear probing with a table with m entries (m is prime) is:

- A. $O(\log m)$ B. m C. $m(m-1)$ D. $m!$

19. The following matrix was produced by Warshall's algorithm with successors. How many edges are on the represented path from 0 to 1?

-1	3	3	3	3
-1	3	3	3	4
-1	1	1	1	4
-1	2	2	2	2
-1	-1	-1	-1	-1

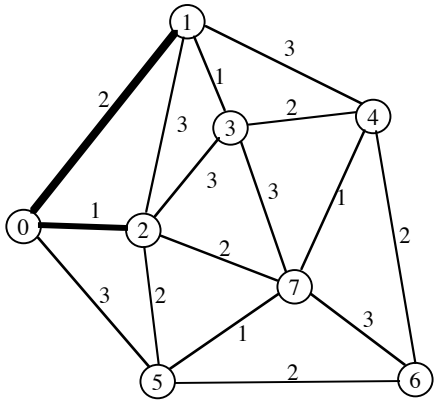
- A. 0 B. 1 C. 2 D. 3

20. Which of the following is not true about probe sequences for an implementation of double hashing?

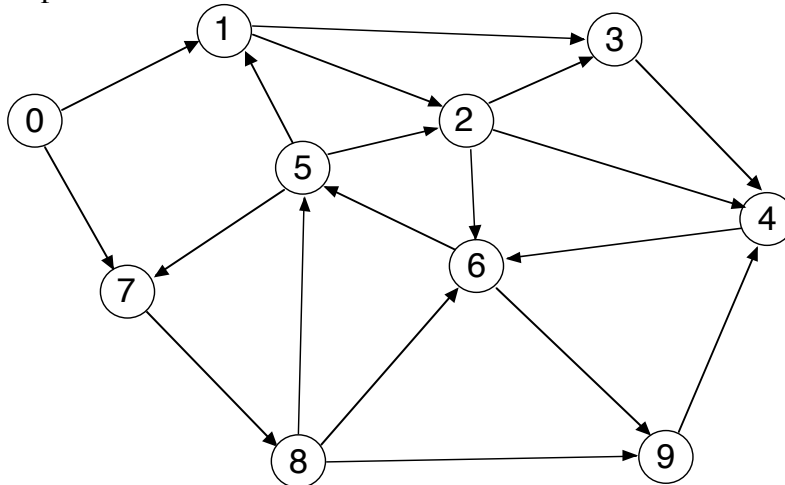
- A. All slots in the hash table appear in each probe sequence
 B. Every key has a probe sequence different from the probe sequences for other keys
 C. The elements of a probe sequence are subscripts in the hash table
 D. The probe sequence for a key cannot change

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. 10 points.



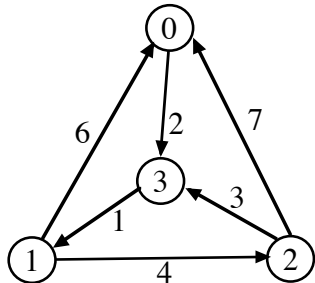
2. Perform depth-first search on the following graph, including start/finish times and edge types (T=tree, B=back, C=cross, F=forward.) Assume that the adjacency lists are **ordered**. Write your answer in the tables below. 10 points



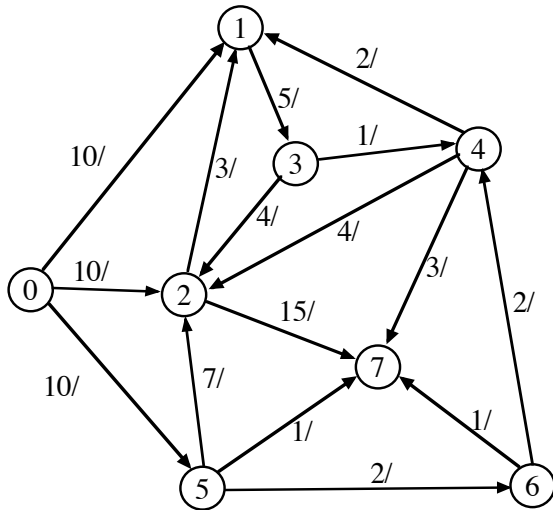
Vertex	Start	Finish	Edge	Type	Edge	Type
0	<u>1</u>	___	0 1	___	5 2	___
1	___	___	0 7	___	5 7	___

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

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.



Minimum Cut:

S vertices: 0
T vertices: 7

Augmenting Paths and Contribution to Flow:

5. Consider the following hash table whose keys were stored by double hashing using

$h_1(\text{key}) = \text{key} \% 13$ and $h_2(\text{key}) = 1 + (\text{key} \% 12)$.

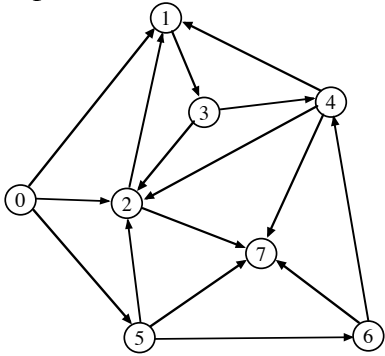
0	1	2	3	4	5	6	7	8	9	10	11	12
			120	186	187	162		122	110			194

a. Give the number of probes needed to find each of the seven stored keys (using double hashing). (7 points)

120 _____ 186 _____ 187 _____ 162 _____
122 _____ 110 _____ 194 _____

b. Suppose 135 is to be inserted (using double hashing). Which slot will be used? (3 points)

6. Perform a breadth-first search on the following graph listing the BFS number, shortest path distance (hops) from the source (0), and the predecessor for each vertex. Assume that the adjacency lists are **ordered**. 10 points



Vertex	BFS Number	Distance	Predecessor
0	_____	_____	_____
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____