CSE 2320
Test 3
Fall 2017

Name Key
Your name as it appears on your UTA ID Card

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

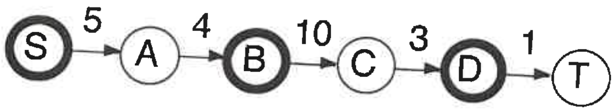
1. Suppose the compressed adjacency list representation is used for a directed graph with n vertices and m edges. The value stored at the last entry of the tailTab is:

C A. n B. $n + 1$ C. m D. $m + 1$

2. What is the expected number of probes for an unsuccessful search in hashing by chaining when there are 2000 items stored in a structure with 100 linked lists?

C A. 10 B. 15 C. 20 D. 50

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



C A. 1 B. 10 C. 16 D. 23

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 Y to X, then its type will be:

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

5. Which of the following cannot occur when additional edges are included in a directed graph?

D A. The graph acquires a cycle.
B. The number of strong components may remain the same.
C. The number of strong components may decrease.
D. The number of strong components may increase.

6. For a double hash table with $\alpha = 0.9$ (without deletions), the upper bound on the expected number of probes for unsuccessful search is:

D A. 1.2 B. 2 C. 5 D. 10

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

C A. `i` and `j` are leaders for the same subset
B. `i` and `j` are in the same subset
C. `i` and `j` are leaders for different subsets
D. `i` is the ancestor of `j` in one of the trees

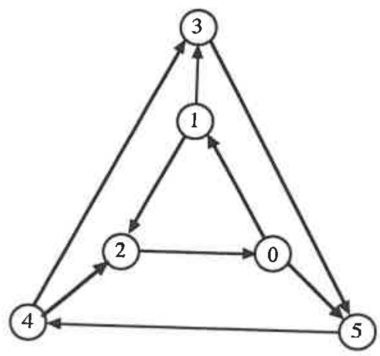
8. Suppose a directed graph has a path from vertex X to vertex Y, but no path from vertex Y to vertex X. The relationship between the finish times for depth-first search is:

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

9. The cycle property for minimum spanning trees may be used to find an MST by:

__C__ 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 edge in any cycle until only a tree of edges remains.
D. Remove the minimum weight edge in any cycle until only a tree of edges remains.

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



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

11. Which algorithm maintains multiple subtrees?

__B__ A. Dijkstra's B. Kruskal's C. Prim's D. Warshall's

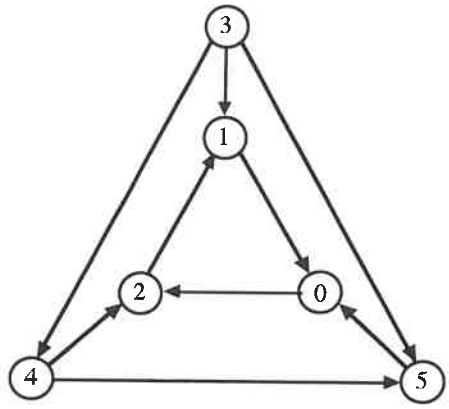
12. Before searching for a minimum cut in a network, it is useful to do the following:

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

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

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

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

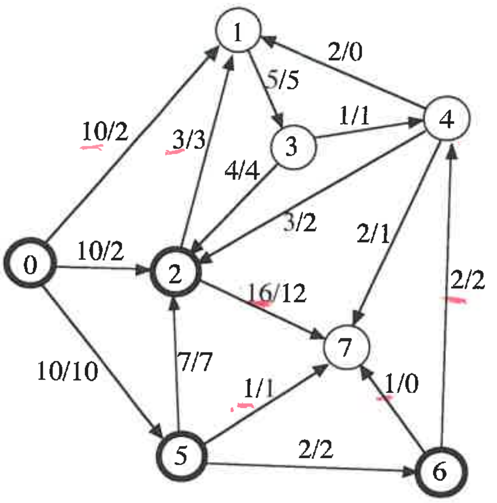


D A. 1 B. 2 C. 3 D. 4

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

B A. $\Theta(V + E)$ B. $\Theta(E \log V)$ C. $\Theta(V \log V)$ D. $\Theta(V \log E)$

Problems 16, 17, and 18 refer to the following network. 0 is the source. 7 is the sink. Each edge is labeled with capacity/flow. (Additional edges for the residual network are not shown.)



16. 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?

C A. $0 \rightarrow 2$ B. $2 \rightarrow 4$ C. $4 \rightarrow 7$ D. Insufficient information

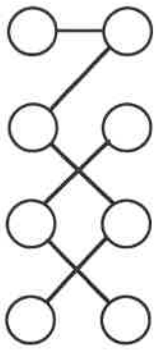
17. The capacity of the indicated cut (S vertices are bold) is:

B A. 32 B. 33 C. 34 D. 35

18. The net flow across the given cut is:

A A. 14 B. 16 C. 18 D. 20

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



B

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

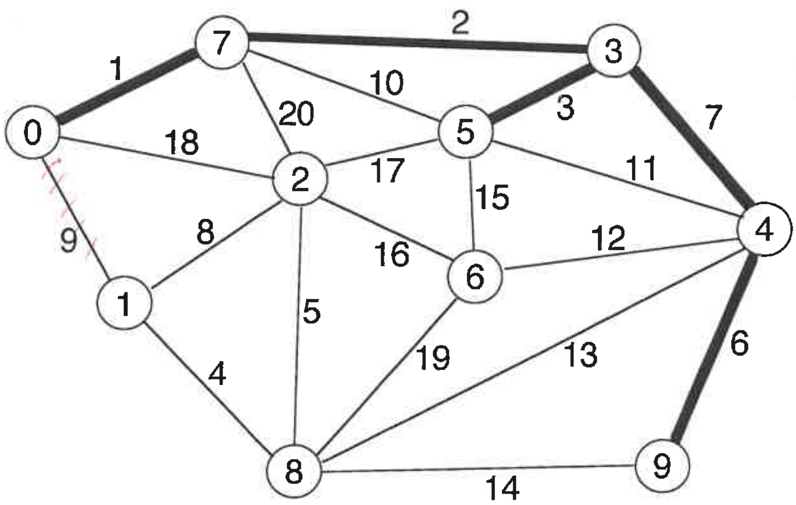
20. What is the Edmonds-Karp variant?

B

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.



Before		After	
1	9(0)	2	8 (1)
2	17(5)	6	12 (4)
6	12(4)	8	4 (1)
8	13(4)		

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	22	
1		
2		142
3	17	
4	4	
5	15	
6	28	
7		
8		
9		130
10	10	

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

142 ÷ 11 = 12, remainder 10 = h_1

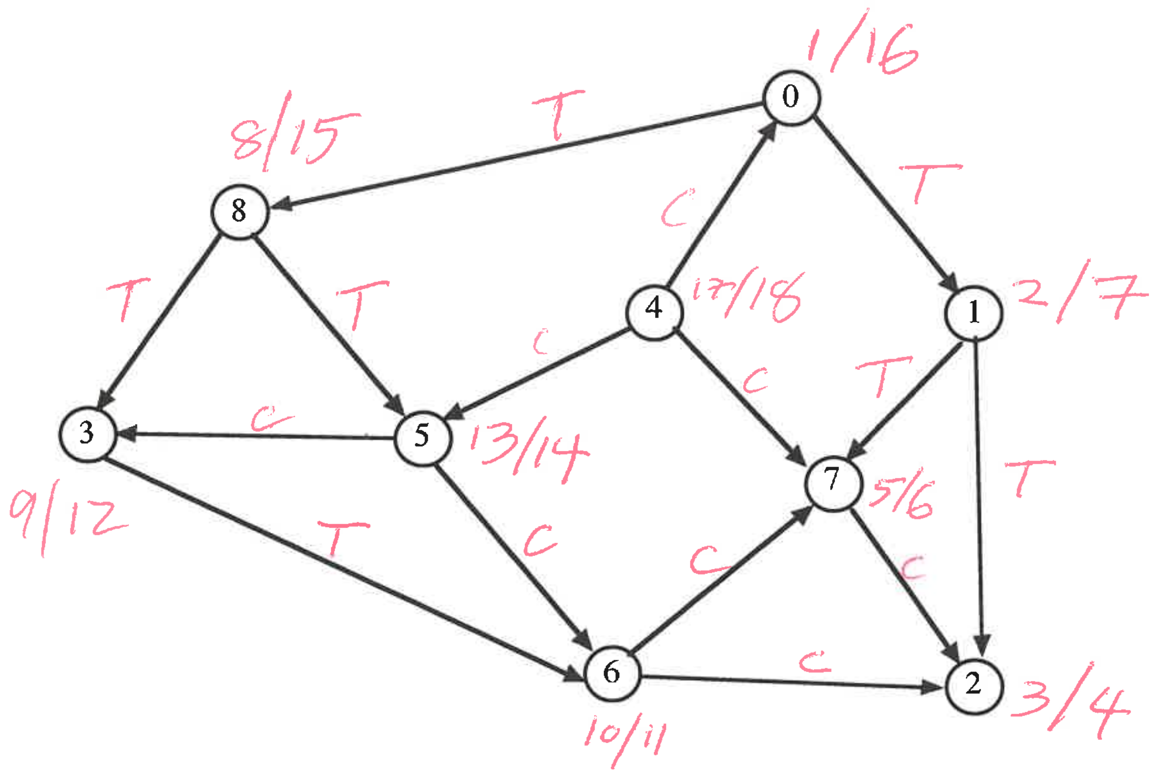
142 ÷ 10 = 14, remainder 2; 2 + 1 = 3 = h_2

10, (2)

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

130 ÷ 11 = 11, remainder (9) = h_1

3. 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 by labeling vertices with discovery and finish times. 10 points



Topological Ordering:

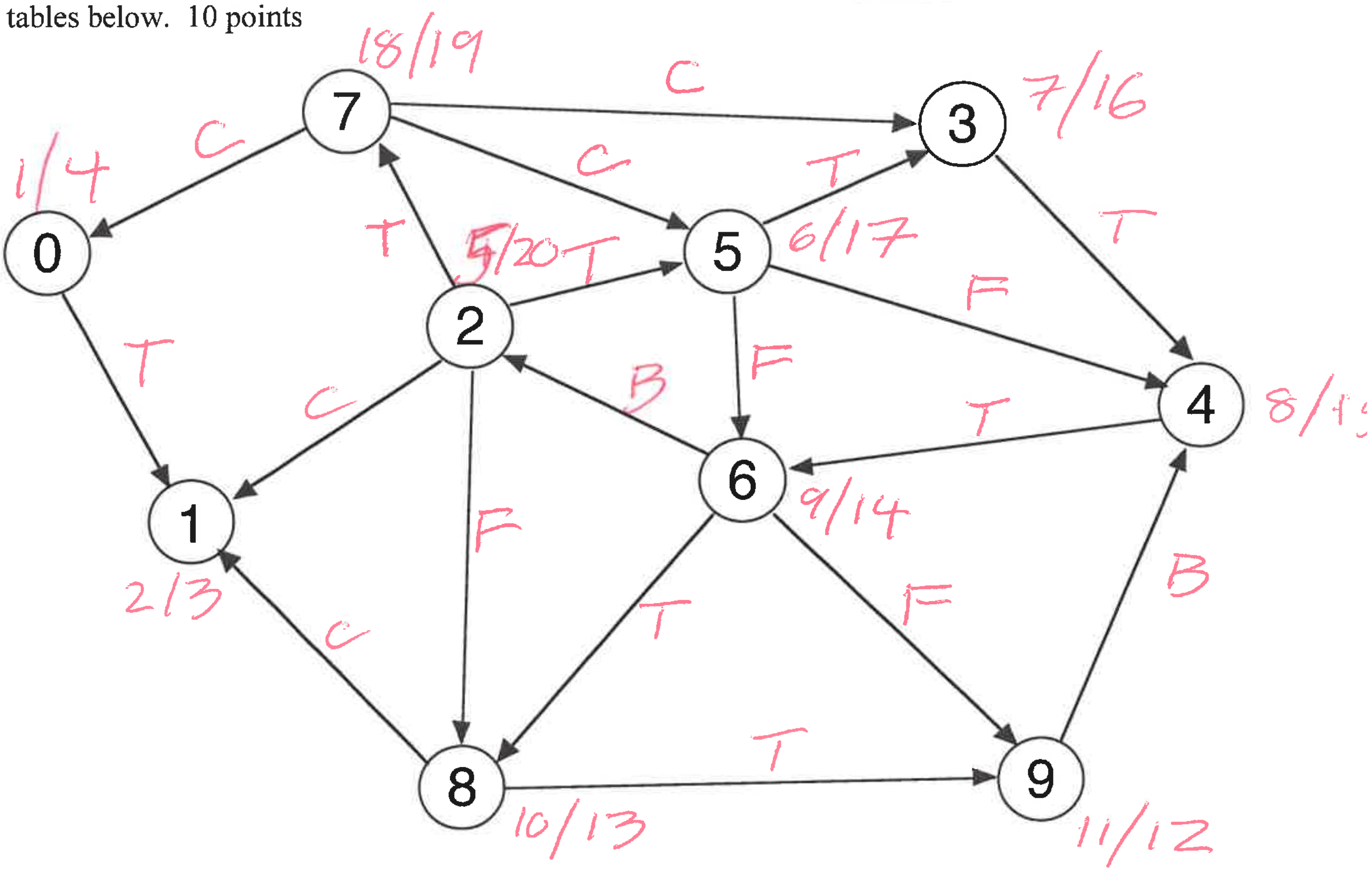
4 0 8 5 3 6 1 7 2

	0		1		2		3		4	
0	11	2	9	2	3	2	8	2	4	4
1	17	4	15	4	9	4	12	3	4	4
2	8	0	6	1	11	0	5	3	10	1
3	15	0	24	0	18	0	23	0	19	0
4	13	2	11	2	5	2	10	2	15	2

4. 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. 10 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

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

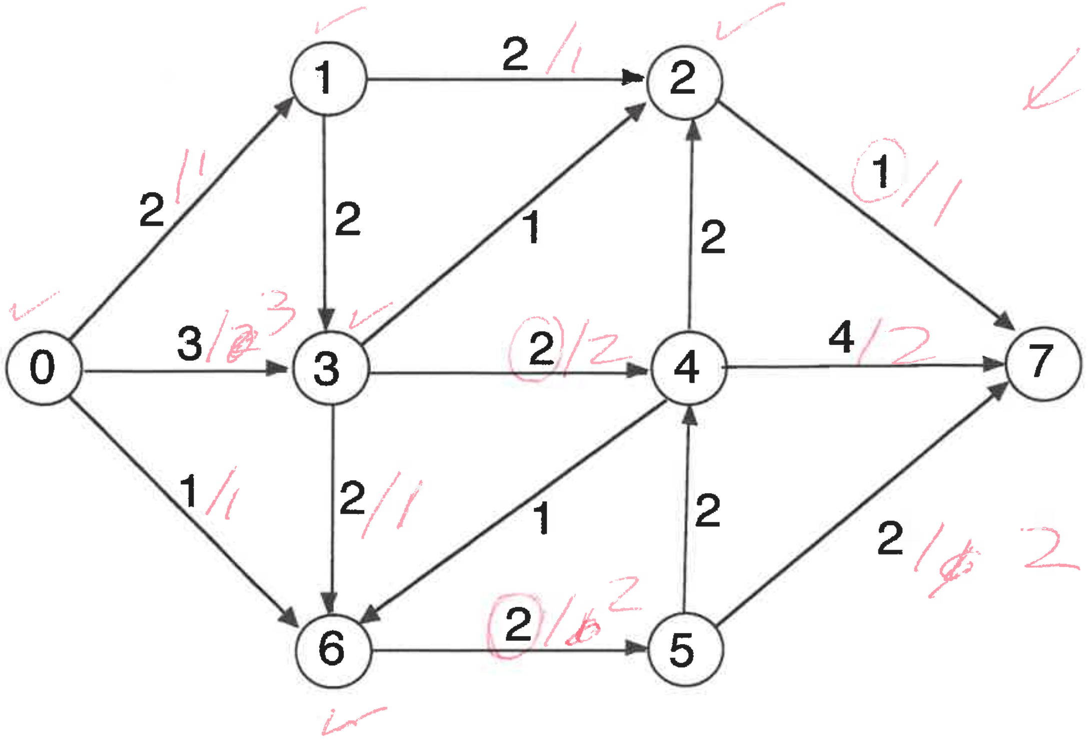


Vertex	Start	Finish
0	1	4
1	2	3
2	5	20
3	7	16
4	8	15
5	6	17
6	9	14
7	18	19
8	10	13
9	11	12

Edge	Type
0 1	T
2 1	C
2 5	T
2 7	T
2 8	F
3 4	T
4 6	T
5 3	T
5 4	F
5 6	F

Edge	Type
6 2	B
6 8	T
6 9	F
7 0	C
7 3	C
7 5	C
8 1	C
8 9	T
9 4	B

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.



Max flow assignment is not unique

Minimum Cut:

S vertices: 0, 1, 2, 3, 6

T vertices: 7, 4, 5

Unique

Augmenting Paths and Contribution to Flow:

0, 1, 2, 7 / 1

0, 3, 4, 7 / 2

0, 6, 5, 7 / 1

0, 3, 6, 5, 7 / 1

Not Unique

$\Sigma = 5$ Unique