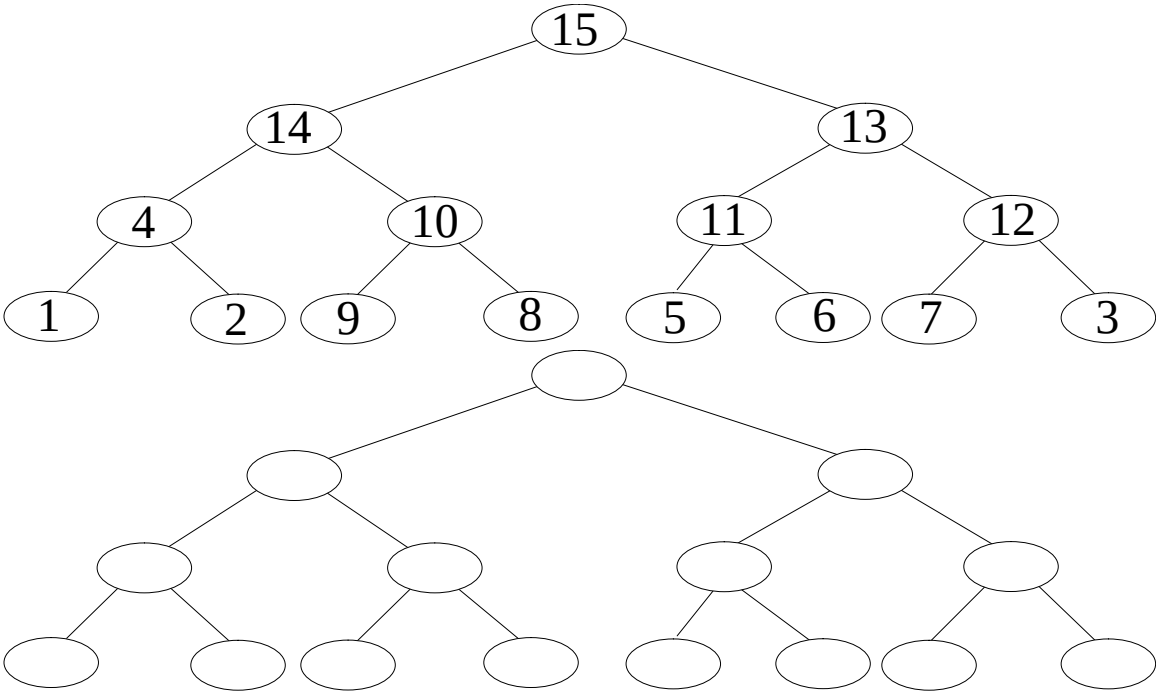
CSE 2320-001 Name _____
Test 1
100 points UTA Student ID # _____

Multiple Choice. Write your answer to the LEFT of each problem. 5 points each

1. The k largest numbers in a file of n numbers can be found using $\Theta(k)$ memory in $\Theta(n \lg k)$ time using
   a. heap
   b. insertion sort
   c. mergesort
   d. PARTITION
2. Let f(n) and g(n) be asymptotically positive functions. Which of the following is true?
   a. $f(n) = \Theta(f(n/2))$
   b. $f(n) = O(g(n))$ implies $g(n) = \Omega(f(n))$
   c. $f(n) = O(g(n))$ implies $g(n) = O(f(n))$
   d. $f(n) + g(n) = \Theta(\min(f(n),g(n))$
3. Stirling's approximation is needed to establish which result?
   a. $H_n = \ln n + O(1)$
   b. $\lg(n!) = \Theta(n \lg n)$
   c. $n! = 1 \bullet 2 \bullet 3 \bullet \ldots \bullet n$
   d. $a^{\log_b c} = c^{\log_b a}$
4. Which of the following sorts is stable?
   a. heapsort
   b. insertion
   c. quick
   d. shell
5. Which of the following sorts does not use time in $\Theta(n \lg n)$ in the average case?
   a. heapsort
   b. insertion
   c. merge
   d. quick
6. Suppose $\lim_{n \to \infty} \frac{f(n)}{g(n)} = \text{constant} > 0$. Which of the following does not hold?
   a. $f(n) = O(g(n))$
   b. $f(n) = \Omega(g(n))$
   c. $f(n) = o(g(n))$
   d. $f(n) = \Theta(g(n))$
7. The worst-case time for BUILD-MAX-HEAP is:
   a. $\Theta(\lg n)$
   b. $\Theta(n)$
   c. $\Theta(n \lg n)$
   d. $\Theta(n^2)$
8. Suppose that UTA President Robert Witt would like all current students listed in descending order based on the number of A grades on each student's transcript. Theoretically, the fastest sort for doing this is:
   a. counting
   b. merge
   c. quick
   d. radix

Long Answer.

1. Use the recursion-tree method to show that $T(n) = 2T(n/2) + 1$ is in $\Theta(n)$. 15 points
2. Use the substitution method to show that $T(n) = 3T(n/3) + 2$ is in $\Theta(n)$. 15 points
3. Demonstrate EXTRACT-MAX on the following max-heap by giving the resulting heap. 10 points.




4. Suppose that file 1 and file 2 each contain a set of positive integers in ascending order . File 3 is supposed to contain the union of the sets represented in files 1 and 2, again in ascending order. Give pseudocode for an algorithm to verify that file 3 is correct. To read file i, you may simply call the function `readFile(i)`, which will return the next integer from file i. If the file has been exhausted, `readfile` will return `-1`. 20 points

CSE 2320-002 Name _____

Test 1

100 points UTA Student ID # _____

Multiple Choice. Write your answer to the LEFT of each problem. 5 points each

1. The k largest numbers in a file of n numbers can be found $\Theta(n)$ average time using
   a. heap
   b. insertion sort
   c. mergesort
   d. PARTITION
2. Which of the following is true?
   a. $n = \Theta(n \lg n)$
   b. $n = O(n \lg n)$
   c. $n \lg n = O(n)$
   d. $n = \Omega(n \lg \lg n)$
3. Stirling's approximation is needed to establish which result?
   a. $H_n = \ln n + O(1)$
   b. $\lg(n!) = \Theta(n \lg n)$
   c. $n! = 1 \bullet 2 \bullet 3 \bullet \ldots \bullet n$
   d. $a^{\log_b c} = c^{\log_b a}$
4. Which two sorts have features that are useful for developing external (e.g. disk) sorts?
   a. heap and shell
   b. heap and merge
   c. quick and counting
   d. quick and merge
5. Suppose an ordered table with n elements may have repeated keys. The worst-case time for determining the number of repeats, k, for a particular key is
   a. $\Theta(k)$
   b. $\Theta(\log k)$
   c. $\Theta(\log n)$
   d. $\Theta(k \log k)$

6. Suppose $\lim_{n \to \infty} \frac{f(n)}{g(n)} = 0$. Which of the following holds?

   a. f(n) = O(g(n))
   b. f(n) = Ω(g(n))
   c. f(n) = ω(g(n))
   d. f(n) = Θ(g(n))

7. The worst-case time for PARTITION is:
   a. Θ(lg n)
   b. Θ(n)
   c. Θ(n lg n)
   d. $\Theta(n^2)$

8. Which of the following is not true about shellsort on n records?
   a. After h-sorting for the first h value, the largest key will be last in the array.
   b. Each group for an h value is sorted using insertion sort.
   c. Each value in the sequence of h values is smaller than n.
   d. The sequence of h values ends with 1.

Long Answer.

1. Use the recursion-tree method to show that T(n) = 3T(n/3) + 2 is in Θ(n). 15 points
2. Use the substitution method to show that T(n) = 2T(n/2) + 1 is in Θ(n). 15 points
3. Demonstrate PARTITION on the following array. 10 points.

   9 6 5 1 7 8 2 3 4

4. Suppose that file 1 and file 2 each contain a set of positive integers in ascending order . File 3 is supposed to contain the intersection of the sets represented in files 1 and 2, again in ascending order. Give pseudocode for an algorithm to verify that file 3 is correct. To read file i, you may simply call the function `readFile(i)`, which will return the next integer from file i. If the file has been exhausted, `readfile` will return `-1`. 20 points

CSE 2320-001 Name _____

Test 2

100 points UTA Student ID # _____

Multiple Choice. Write your answer to the LEFT of each problem. 5 points each

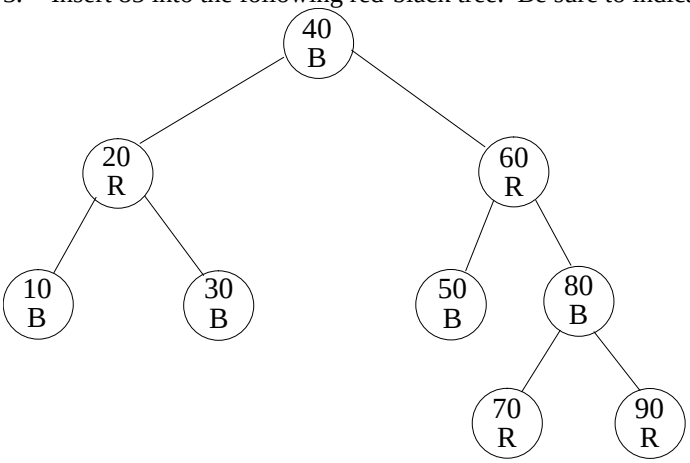
1. Which traversal will list the keys in a binary search tree in ascending order?
   A. inorder
   B. level-by-level
   C. postorder
   D. preorder
2. Which data structure operates in last-in-first-out fashion?
   A. hashing with chaining
   B. hashing with open addressing
   C. queue
   D. stack
3. Ordered linked lists are useful when:
   A. a free storage list is being used for freed nodes
   B. deletions are to be supported
   C. hits dominate misses
   D. misses dominate hits
4. What data structures are needed for an infix calculator?
   A. A stack and a queue
   B. A red-black tree
   C. Two queues
   D. Two stacks
5. Suppose that you are deciding whether an ordered linked list (ascending order) should be singly or doubly linked. Which of the following operations can be done faster if double linking is used?
   A. Deleting a node
   B. Finding the node with the minimum key
   C. Finding the node for a key
   D. Finding the successor of a node
6. 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 $\theta(n^2)$ time for the entire sequence?
   A. linear hash table
   B. ordered linked list
   C. red-black tree

D. unbalanced binary search tree

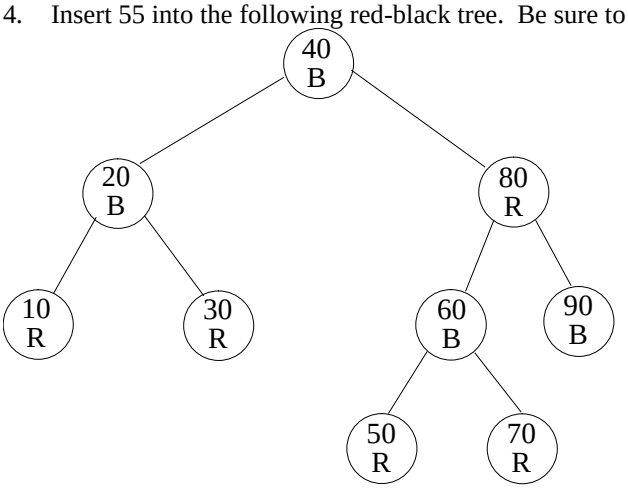
7. Circular linked lists are occasionally useful because
   A. some operations may be done in constant time.
   B. they are an alternative to red-black trees
   C. they are useful for implementing circular queues.
   D. they avoid malloc()s
8. Quadratic probing has the property that
   A. Primary clustering is reduced
   B. Secondary clustering is reduced
   C. Both primary clustering and secondary clustering are reduced
   D. Neither primary clustering nor secondary clustering is reduced

Long Answer. 10 points each

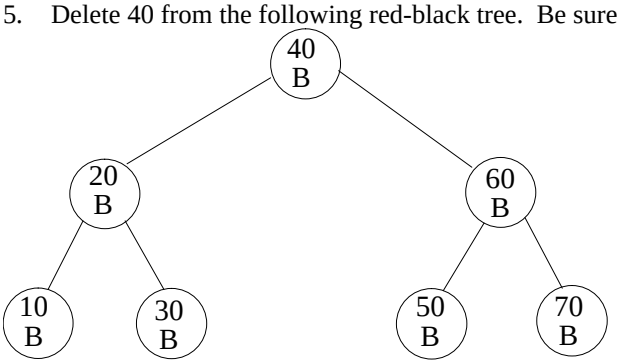
1. Give an example of a binary search tree whose nodes cannot be assigned colors to make it a legal red-black tree.
2. Suppose you are using double hashing. What is the maximum load factor that may be used to assure that the expected number of probes for an unsuccessful search does not exceed 3?
3. Insert 85 into the following red-black tree. Be sure to indicate the cases that are used.



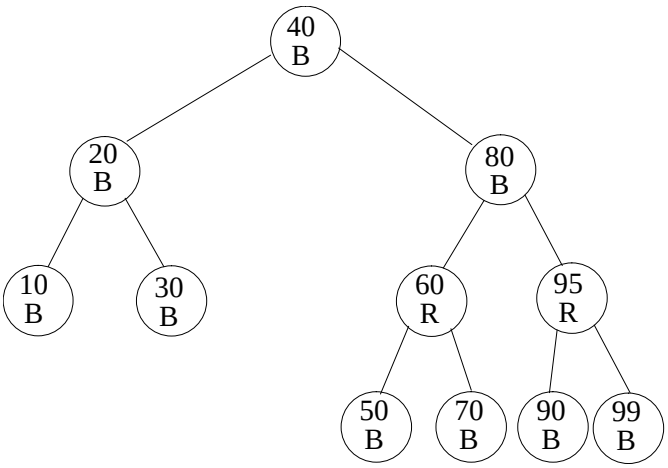

4. Insert 55 into the following red-black tree. Be sure to indicate the cases that are used.




5. Delete 40 from the following red-black tree. Be sure to indicate the cases that are used.




6. Delete 30 from the following red-black tree. Be sure to indicate the cases that are used.




CSE 2320-002 Name _____

Test 2

100 points UTA Student ID # _____

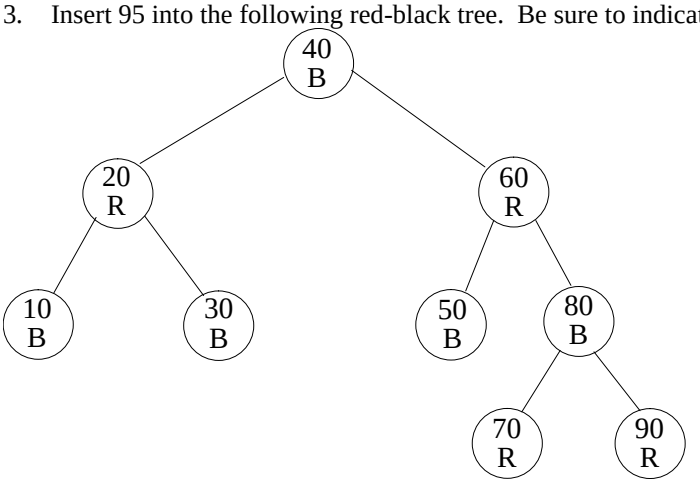
Multiple Choice. Write your answer to the LEFT of each problem. 5 points each

1. Suppose that you are deciding whether an ordered linked list (ascending order) should be singly or doubly linked. Which of the following operations can be done faster if double linking is used?
   A. Deleting a node
   B. Finding the node with the minimum key
   C. Finding the node for a key
   D. Finding the successor of a node
2. Suppose that a sequence of n keys will be inserted into an initially-empty instance of the following data structures. Which of the following takes $\theta(n \lg n)$ time for the entire sequence?
   A. linear hash table
   B. ordered linked list
   C. red-black tree
   D. unbalanced binary search tree
3. Which traversal will list the keys in a binary search tree in ascending order?
   A. inorder
   B. level-by-level
   C. postorder
   D. preorder
4. Which data structure operates in first-in-first-out fashion?
   A. hashing with chaining
   B. hashing with open addressing
   C. queue
   D. stack
5. Ordered linked lists are useful when:
   A. a free storage list is being used for freed nodes
   B. deletions are to be supported
   C. hits dominate misses
   D. misses dominate hits
6. Where is a sentinel used with a linked list?
   A. anywhere
   B. at the beginning
   C. at the end
   D. before the node with the smallest key
7. Linear probing has the property that
   A. Primary clustering occurs frequently
   B. Secondary clustering occurs frequently
   C. Both primary clustering and secondary clustering occur frequently
   D. Neither primary clustering nor secondary clustering occur frequently
8. Circular linked lists are occasionally useful because
   A. some operations may be done in constant time.
   B. they are an alternative to red-black trees
   C. they are useful for implementing circular queues.
   D. they avoid malloc()s

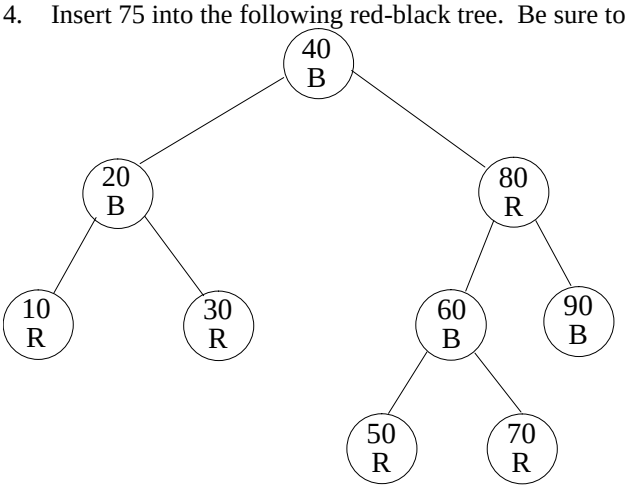
Long Answer. 10 points each

1. Give an example of a binary search tree with at least five nodes, but does not have any red nodes..

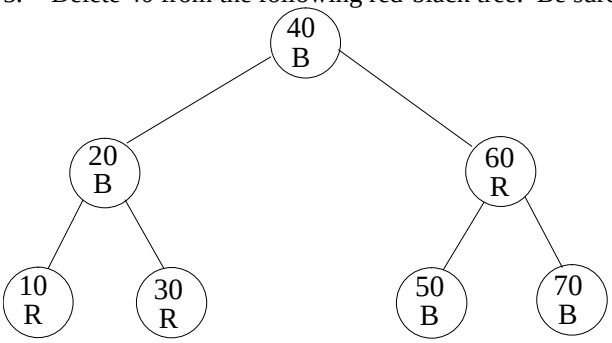
2. Suppose you are using double hashing. What is the maximum load factor that may be used to assure that the expected number of probes for an unsuccessful search does not exceed 10?
3. Insert 95 into the following red-black tree. Be sure to indicate the cases that are used.



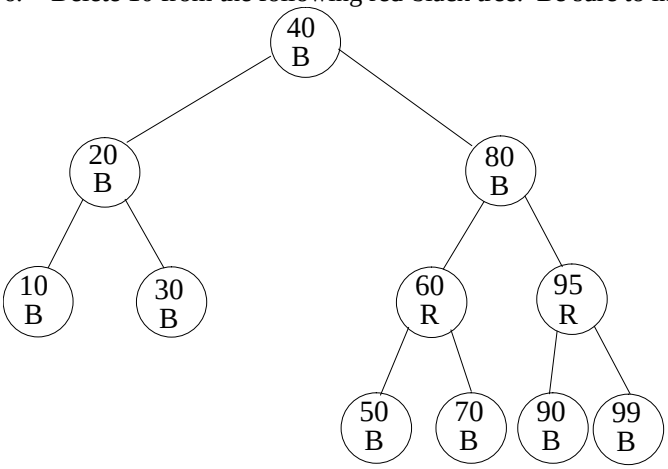

4. Insert 75 into the following red-black tree. Be sure to indicate the cases that are used.




5. Delete 40 from the following red-black tree. Be sure to indicate the cases that are used.




6. Delete 10 from the following red-black tree. Be sure to indicate the cases that are used.



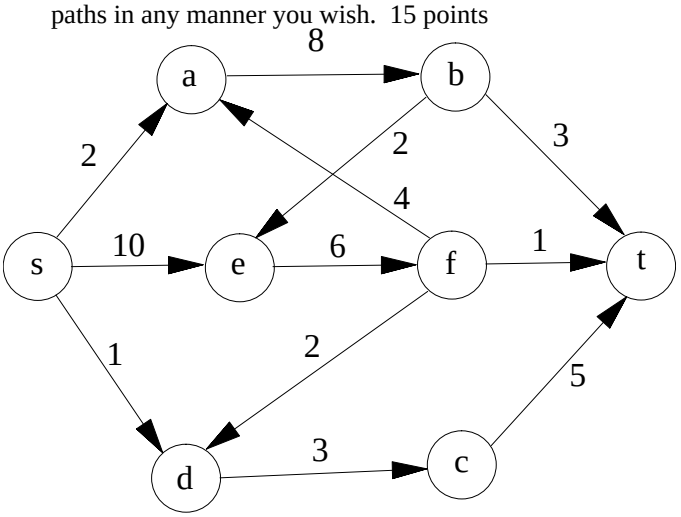
CSE 2320-001 Name _____

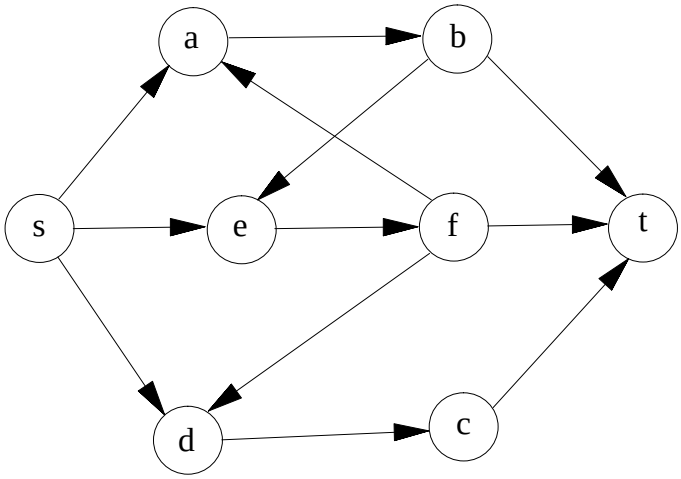
Test 3

1. Give both KMP fail link tables for the given pattern . 15 points

a
b
c
d
a
b
c
a
b
c
d
a
b
c
d
a
b
c
d
a
b
c

2. For the given network, determine a maximum flow and the minimum cut. Be sure to give each augmenting path, the amount of additional flow that it provides, and the residual graph after each augmenting path is recorded. You may choose the augmenting paths in any manner you wish. 15 points



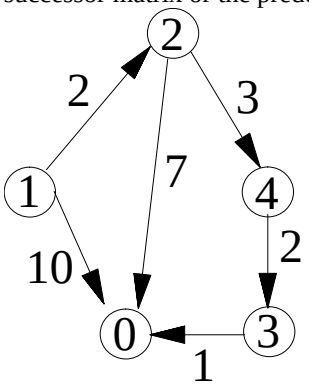




Augmenting Path/Flow:

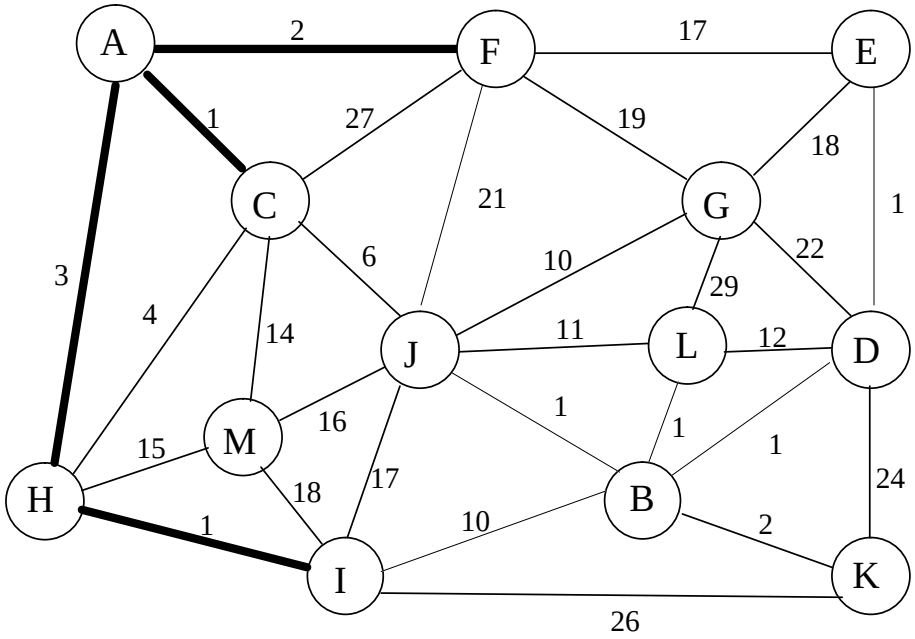
.
.
.

Minimum Cut:

3. Use dynamic programming to determine the longest common subsequence of `10011001` and `01011110`. 10 points
4. Demonstrate the Floyd-Warshall algorithm the following graph. In addition to the path length matrix, you must give either the successor matrix or the predecessor matrix. 10 points




5. 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

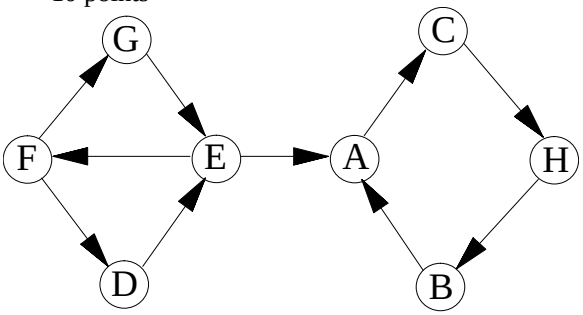



6. Complete the following instance of the optimal matrix multiplication ordering problem, including the tree showing the optimal ordering. 10 points

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

| | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 100 | 1 | 120 | 1 | ??? | ? |
| 2 | ------- | | 0 | 0 | 60 | 2 | 132 | 3 |
| 3 | ------- | ------- | | 0 | 0 | 90 | | 3 |
| 4 | ------- | ------- | ------- | | 0 | 0 | | |

7. Suppose that an augmenting path for the maximum flow problem is to maximize the amount of additional flow that the AP provides. Describe a greedy algorithm that solves this problem. 10 points
8. Demonstrate the technique that uses two depth-first searches to find the strongly-connected components of the following graph. 10 points




9. For each of the previous eight problems, give the worst-case time for the relevant algorithm. 10 points
   1. (KMP)
   2. (Max flow)
   3. (LCS)
   4. (Floyd-Warshall)
   5. (MST)
   6. (Optimal matrix multiplication)
   7. (Greedy maximum AP)
   8. (SCCs)

CSE 2320-002 Name _____

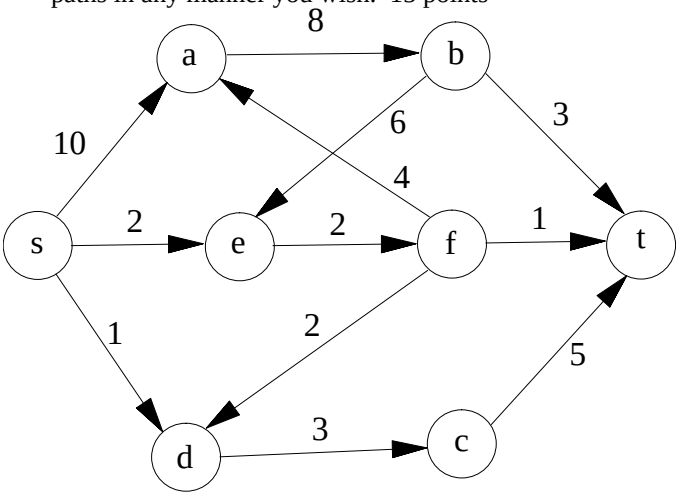
Test 3

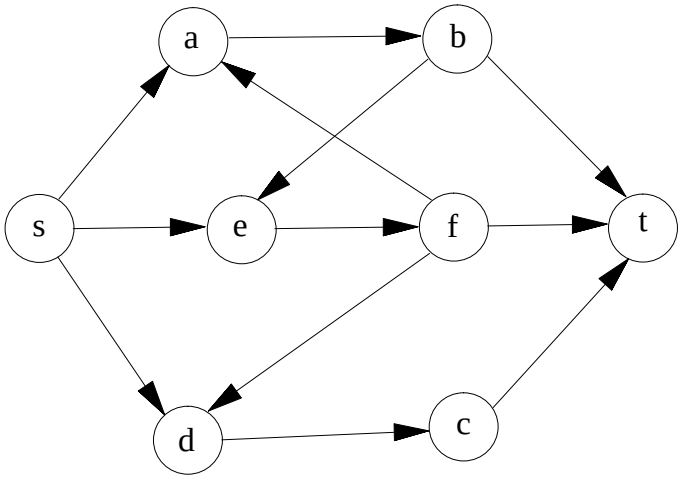
1. Give both KMP fail link tables for the given pattern. 15 points

```
a
a
a
```

b
a
a
a
a
a
b
a
a
a
b
a
a

2. For the given network, determine a maximum flow and the minimum cut. Be sure to give each augmenting path, the amount of additional flow that it provides, and the residual graph after each augmenting path is recorded. You may choose the augmenting paths in any manner you wish. 15 points




Augmenting Path/Flow:

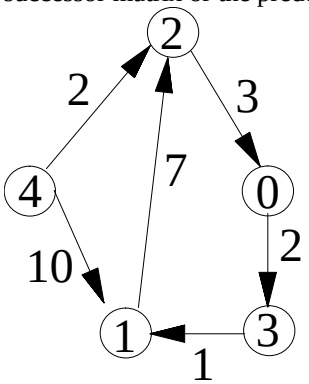
.

.

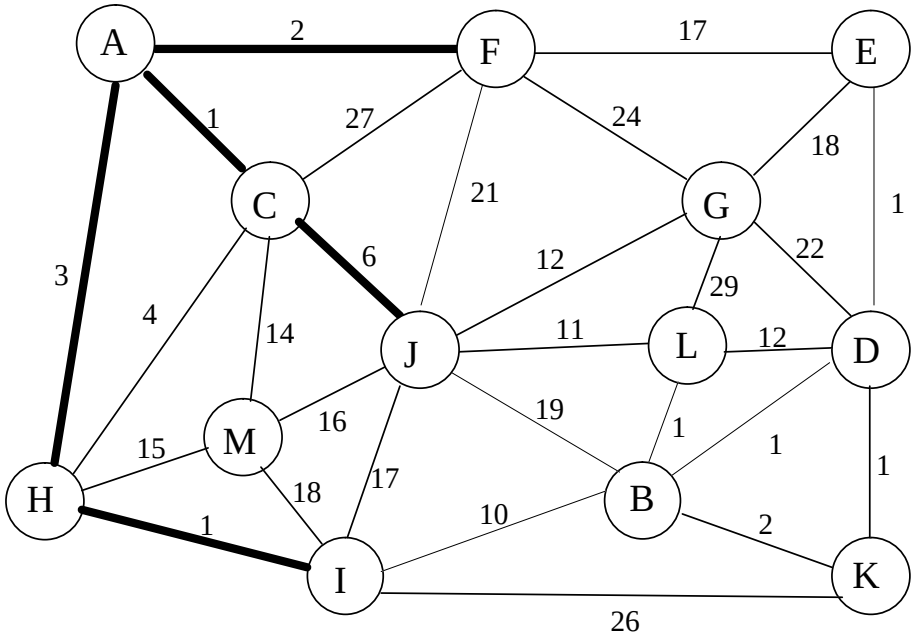
.

Minimum Cut:

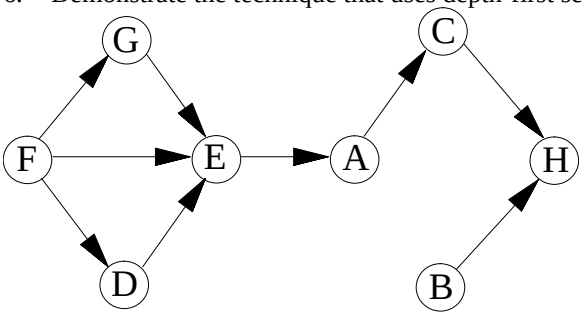
3. Use dynamic programming to determine the longest common subsequence of `aabbccdd` and `abcdabcd`. 10 points
4. Demonstrate the Floyd-Warshall algorithm on the following graph. In addition to the path length matrix, you must give either the successor matrix or the predecessor matrix. 10 points




5. 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




6. Demonstrate the technique that uses depth-first search to topologically sort the vertices in the following graph. 10 points




7. Discuss the difference between the fractional and 0/1 knapsack problems. 10 points
8. Give an optimal Huffman code tree for the provided symbols and probabilities. In addition, compute the expected number of bits per symbol. 10 points

```
A  .15
B  .3
C  .05
D  .1
E  .2
F  .1
G  .1
```

9. For each of the previous eight problems, give the worst-case time for the relevant algorithm. 10 points
    1. (KMP)
    2. (Max flow)
    3. (LCS)
    4. (Floyd-Warshall)
    5. (MST)
    6. (Topological sort)
    7. (Knapsack)
    8. (Huffman code tree construction)