CS-160 **Final Exam** **May 18, 2016**

This Exam is being given under the guidelines of the **Honor Code**. You are expected to respect those guidelines and to report those who do not. Answer the questions in the spaces provided. If you run out of room for an answer, continue on the back of the page. There are 13 questions for a total of 134 points.

Name: _____

1. (5 points) Which of the following algorithms and/or data structures could be used to implement the Map ADT (That is, a data structure that acts like a Python dictionary)?

   - A List and the Binary Search algorithm.
   - A Heap
   - A Binary Search Tree
   - A Hash Table
   - A Stack

2. (2 points) Which of the above possibilities would be the best choice

3. (3 points) What are the three laws of recursion?

4. (10 points) Given the following list L = [1, 3, 5, 7, 9, 11, 13, 17, 19, 23] write down each comparison that the `binarySearch` algorithm would do when searching for the key 7.

5. (10 points) A palindrome is a string that reads the same both forward and backward. We can ignore punctuation marks and white space. Palindromes have been around since biblical times. For example, when Adam and Eve first met Adam is quoted as saying "madam I'm adam". Later in history a large engineering feat in central america was described as: "a man a plan a canal panama". When the use of electricty became widespread, engineers were often heard muttering "so many dynamos". More simply, "abcba" is a palindrome. Write a recursive function `pal(s)` to dermine whether a given string is a palindrome. For example: `pal(palprep("radar"))` would return true, whereas `pal("palindrome")` would return false. *Hint: a zero or one character string is always a palindrome, a two character string is a palindrom if the two characters are the same... And, don't forget how to slice*

6. Given the following list of numbers x = [13, 24, 5, 7, 9, 17, 32, 27, 2]

   (a) (10 points) Create a binary search tree and insert each of the numbers. Draw a picture of the final tree. You do not need to show all the intermediate trees, just the final.

   (b) (10 points) Create a binary min-heap and insert the numbers one at a time into the heap. Draw both the tree and list representation of the heap after all the numbers are inserted.

7. (10 points) Given the following set of hash keys show the resulting hash table assuming that you are using linear probing. Insert them in order from left to right. The table holds exactly 11 keys. You do not need to worry about growing the table.

| 113 | 117 | 97 | 100 | 114 | 108 | 116 | 105 | 99 |

0	1	2	3	4	5	6	7	8	9	10

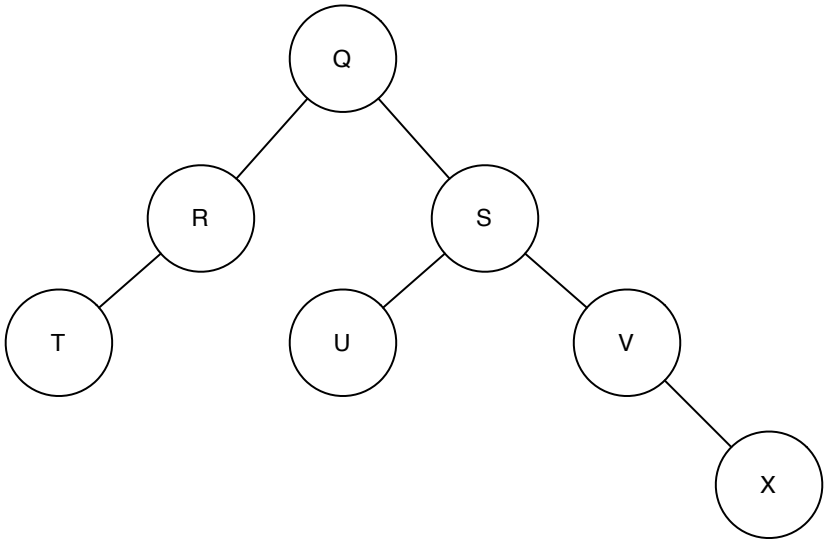
8. (10 points) Given the following list L = [90, 1, 3, 8, 56]. Show the contents of L after each pass of Insertion sort. I'll give you pass 1 for free!

90	1	3	8	56

9. (10 points) Given the following list L = [90, 1, 3, 8, 56, 21, 5, 13, 1, 146, 2, 34]. Show the contents of L after the After all the swapping is done for a gap size of 3 using Shell sort.

90	1	3	8	56	21	5	13	1	146	2	34

10. Given the binary tree shown below:



(a) (5 points) Perform a pre-order traversal of the tree. Write out the name of each node in the order it is visited.

(b) (5 points) Perform a post-order traversal of the tree. Write out the name of each node in the order it is visited.

(c) (5 points) Draw the list of lists representation for the tree rooted at node "s".

11. Yertlenet is a primitive form of networking that was used at Luther college up until the mid 1980's. Yertlenet uses turtles as a message transport mechanism and requires that special one-way channels be dug between the buildings on campus to facilitate turtle navigation. A Message is routed from building x to building y by placing a message on the back of a turtle and setting the turtle in the channel leading to the next building. To facilitate routing, each building employed a student worker to receive incoming messages and if necessary move the turtle to the channel leading to the next building.

    You have just been hired as the new student worker for building one. Being a CS major you decide that you want to be the best turtle router on campus and therefore will create a graph of Yertlenet and figure out the optimum routing for messages that come through your building. The following table shows the information describing the Yertlenet connections. Column one is the start building, column two is the end building, and column three is the cost of the link.

```
1 2 10
1 3 15
1 6 5
2 3 2
3 4 7
3 6 10
4 5 7
6 4 5
5 6 13
```

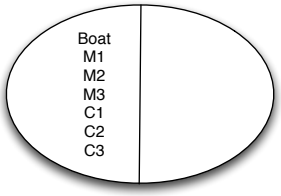
    (a) (5 points) Draw the directed graph represented by the above table.

    (b) (12 points) Using Dijkstras algorithm, find the shortest path from each other building on campus to yours. Fill in the table below when you are done. You do not need to show every step of the algorithm, but make sure you show changes to the priority queue.

node	dist	pred
1		
2		
3		
4		
5		
6		

12. Consider the following classic problem: There are three missionaries and three cannibals on the left bank of a river. They wish to cross over to the right bank using a boat that can only carry two at a time. Either a missionary or a cannibal can row the boat. However, the number of cannibals on either bank must never exceed the number of missionaries or the missionaries are toast.

    This problem can be solved using a graph search algorithm. The key is to recognize that the nodes in the graph represent a "configuration" of the problem, with certain things on one side of the river and certain things on the other. Edges between nodes represent legal movements of items from one side to the other. The following diagram illustrates the starting space for this problem with the boat and all missionaries and cannibals on the left side of the river.



(a) (10 points) Draw a graph to show all the legal states that could come right after the start state. Then pick one of those states and show the next set of legal states.

(b) (2 points) Which Graph algorithm would you use to find the smallest number of crossings?

13. (10 points) Given the following directed graph, draw the adjacency matrix representation of the graph. You can assume that the weights for all the links are 1.