Name: _____

Write all of your responses on these exam pages. If you need extra space please use the backs of the pages.

1   Short Answer (8 Points Each)

1. State the definitions of Big-O, Big-Ω, and Big-Θ.

2. Fill out the time complexity table below.

Algorithm	Best	Average	Worst
Bubble Sort			
Insertion Sort			
Selection Sort			
Quick Sort			
Merge Sort			

3. Suppose the following values are inserted into a binary tree, in the order given: 12, 7, 9, 10, 22, 24, 30, 18, 3, 14, 20

   (a) Draw a diagram of the resulting binary tree.

   (b) Display an in-order traversal of the tree.

   (c) Display a pre-order traversal of the tree.

   (d) Display a post-order traversal of the tree.

4. Write a recursive function to calculate the factorial of a parameter input. Recall that the factorial is defined as, $0! = 1$ and for $n > 0$ we have $n! = 1 \cdot 2 \cdot 3 \cdots (n - 1) \cdot n$

5. Write a recursive function to calculate the nth Fibonacci number. Recall that the Fibonacci sequence is defined as, $F_0 = 1$, $F_1 = 1$, and for $n > 1$ we have $F_n = F_{n-1} + F_{n-2}$.

6. Write a recursive function to solve the Towers of Hanoi problem. The setup and initial function call are below.

```
const int FROM_PEG = 1;     // Initial "from" peg
const int TO_PEG = 3;       // Initial "to" peg
const int TEMP_PEG = 2;     // Initial "temp" peg
moveDiscs(NUM_DISCS, FROM_PEG, TO_PEG, TEMP_PEG);
```

7. Answer the following questions about inheritance.

   (a) What is the difference between a protected class member and a private class member?

   (b) Which constructor is called first, that of the derived class or the base class?

   (c) When does static binding take place? When does dynamic binding take place?

   (d) What is an abstract base class?

8. Answer the following True and False questions about inheritance. Circle the correct answer.

   (a)   **T**   **F**   The base class destructor is called after the derived class destructor.

   (b)   **T**   **F**   Protected members of a public base class become public members of the derived class.

   (c)   **T**   **F**   It isn't possible for a base class to have more than one constructor.

   (d)   **T**   **F**   Pointers to a base class may be assigned the address of a derived class object.

9. Find and correct the errors in the following code.

```cpp
class Three : public Two : public One
{
  protected:
    int x;
  public:
    Three() { y = 0 }
    Three(int a, int b, int c), Two(b), Three(c)
      { x == a; }
    ~Two();
};
```

10. What is a purely virtual function and how is it created?

2   Coding (10 Points Each)

Given the following specification for the BinaryTree class and TreeNode class.

```cpp
template <class T>
class BinaryTree
{
 private:
   class TreeNode
    {
     public:
       T value;
       TreeNode *left;
       TreeNode *right;

       TreeNode(T nodeValue)
       {
           value = nodeValue;
           left = nullptr;
           right = nullptr;
       }
   };

   TreeNode *root;

   void insert(TreeNode *&, TreeNode *&);
   void destroySubTree(TreeNode *);
   void deleteNode(T, TreeNode *&);
   void makeDeletion(TreeNode *&);
   void displayInOrder(TreeNode *) const;
   void displayPreOrder(TreeNode *) const;
   void displayPostOrder(TreeNode *) const;

 public:
   BinaryTree() {
       root = nullptr;
   }

   ~BinaryTree() {
       destroySubTree(root);
   }

   void displayInOrder() const {
       displayInOrder(root);
   }

   void displayPreOrder() const {
       displayPreOrder(root);
   }

   void displayPostOrder() const {
       displayPostOrder(root);
   }

   void clear() {
       destroySubTree(root);
       root = nullptr;
   }

   void insertNode(T);
   bool searchNode(T);
   void remove(T);
};
```

Write the implementations of the following functions as they would be written in the cpp file.

- `void displayInOrder(TreeNode *) const`

- `void insert(TreeNode *&, TreeNode *&)`

- `bool searchNode(T)`

1. `void displayInOrder(TreeNode *) const`

2. `void insert(TreeNode *&, TreeNode *&)`

3. `bool searchNode(T)`