The rules for this exam are as follows:

- **Write your name on the front page of the exam booklet.** Initial each of the remaining pages in the upper-right hand corner. **Sign the front of the exam booklet.** Your exam will not be graded if you have not signed the front page of the booklet.

- This exam will last for 50 minutes.

- Show **ALL** work for partial/full credit. This includes any definitions, mathematics, figures, etc.

- The exam is closed book and closed notes.

- No laptops, ipads, or other types of non-medical electronic devices are allowed.

- Calculators are allowed provided that they are only used to perform basic computations (and not programmed with algorithms or notes, for example).

- No collaboration of any kind is allowed on the exam.

1. ______ (10 points)  
2. ______ (10 points)  
3. ______ (10 points)  
4. ______ (10 points)  
5. ______ (10 points)  
6. ______ (10 points)  
EC. ______ (6 points)  
T. ______ (10 points)
1. (10 points) Consider closed hashing with quadratic probing.

   (a) (8 points) Insert 34, 63, 18, 7, 2, 51, 40, and 13 using quadratic probing with hash function $h(x) = x \mod m$, where $m = 11$ and $f_i = i^2$ into an initially empty hash table. **Show your calculations and collision resolutions.**

   (b) (1 point) What is the main disadvantage of closed hashing with quadratic probing?

   (c) (1 point) How should we choose $m$ buckets and the load factor $\lambda$ so as to ensure good performance in this context?
2. (10 points) Given an array \( A \) of length \( n \) and a key \( x \). Assume that \( Pr(x \in A) = q \) and that each outcome in the successful search is equally likely. Based on the number of comparisons between \( x \) and the \( A[i] \)'s, compute \( T_a(n) \) in closed-form if the sequential search algorithm is used for search for \( x \) in \( A \) (starting at \( A[1] \)).

3. (10 points) When implementing an ADT for a set of records \( S \), \( |S| = 3^5 \), it is determined that an insert operation, i.e., \( \text{insert}(x,S) \), will require 0.003 seconds to execute. If the complexity of the insert operation is given by the following closed-form expression \( T(n) \), compute the time required to execute this operation when \( |S| = 3^{15} \).

\[ T(n) = 7 \log n. \]

4. (10 points) Prove that

\[
\frac{2n^3 - 6n + 1}{n^2 - 3} = O(n)
\]

using the definition of big-\( O \). Show all of your work.
5. (10 points) Construct the (unique) binary tree corresponding to the given pair of tree
traversals if possible. If no such tree is possible, construct as much of the tree as
possible, indicate where the breakdown lies, and state that it is not possible.
Preorder: E, C, B, H F, D, L, A, G, K
6. (10 points) Illustrate the data structure for the following tree using the left-child list-of-siblings implementation.

![Tree Diagram]

**OPTIONAL: Extra-Credit Question**

1. (6 points) Draw an example of a binary tree of height 3 that is none of the following: a skew tree, a balanced tree, a complete tree, or a full tree.