Name _____________________

This test is closed book, closed notes, and closed neighbor. Do your work on the paper provided.
Staple the pages together with this sheet on the front when you turn it in.

1. (16 pts - 4 pts each) Define 4 of the following 5 terms. I will grade the first 4 that you give. Be sure to distinguish it from similar concepts.
   a. clone method
   b. NullPointerException
   c. generic class
   d. linked list (draw picture, too)

2. (15 pts - 5 pts each) Short answer. Answer 3 of these 4 questions.
   a. Describe deep and shallow copying and how they affect instance variables. Which class methods tend to use this and why?
   b. What is a class invariant? Give an example from one of the container classes we've examined. When do you think about class invariants and why?
   c. What are generic classes? Why do we use them? What complications do they add to writing classes?
   d. Why would someone use the Java Collections classes? Give some example of classes there. If they are so helpful, why did we write our own classes such as bag and sequence?

3. (15 pts - 5 pts each) Linked Lists raw rather than implementing a class.
   a. Write a print method in Java that takes a reference to Node<E> as its only parameter and prints the data in each node on a separate line. It should not change the linked list.
   b. Draw a picture showing what happens in an addAfter method that adds the item (provided as a parameter) to a new node added after the node given as the parameter pre.
   c. Write the Java code for the addAfter method from part b. This is raw linked list not in a sequence or bag.

4. (20 pts) Implementing Classes with Linked Lists.
   You may assume for this problem that the instance variables of a Bag class implemented with a linked list are head and manyNodes. head is a reference to Node<E> with nodes having E typed data components. manyNodes is an integer indicating the number of items in the bag.
   a. Why might we use a linked list instead of an array? (2 pts)
   b. Write a Bag method count which has the method header of
      public int count (E target)
      that will return an integer containing the number of times target is in the bag. (8 pts)
   c. Write a Bag method that has the method header of
      public Bag copyUnique ( )
      that returns a new bag that contains the same items as in the current Bag but only one copy of each unique item. No, you haven't seen this before. Realize that if the Bag you are creating meets its invariant, you may safely call its methods including insert and the count one in part b. Do not alter the existing Bag. (10 pts)

5. (34 pts) Stacks and Queues
   a. Stacks and queues are similar and different. For each of stack and queue, give a drawing showing how each would be stored in an array and a linked list. Use the characters in your first name (or usual nickname) as the data put into the container as an example for your pictures. Label the accessible element. (4 pictures; 16 pts)
   b. Write Java code for public void add (E entry) for a queue implemented with a linked list as described in the text and lecture. (10 pts)
   c. Use a stack to evaluate the following postfix expression. Show your work so that I can see you are using a stack. You will not receive full credit without appropriate stack pictures. You may not use calculators. (8 pts)

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