COP 3530
Data Structures

Midsemester Exam Version A

Name: _____

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This exam has 4 questions. Each question starts on a new page. Please answer each question on its page. You may assume `java.util` has been imported. There will be no deductions for lack of commenting. There will be no deductions for lack of import directives. There will be no deductions for minor syntax errors.

1. [**50 points**] Method `containsTriplicates` returns true if the array contains three items with the same state, and false otherwise:

```
public static boolean containsTriplicates( Object [ ] arr )
{
    for( int i = 0; i < arr.length; i++ )
        for( int j = i + 1; j < arr.length; j++ )
            if( arr[ i ].equals( arr[ j ] ) )
                for( int k = j + 1; k < arr.length; k++ )
                    if( arr[ j ].equals( arr[ k ] ) )
                        return true;

    return false;
}
```

   (a) What is the Big-Oh running time of `containsTriplicates`?
   (b) If it takes 4 milliseconds to return false for 1000 items, approximately how long would it take to return false for 2000 items?
   (c) Using the Collections API, describe an algorithm (in English, no code) that is more efficient than the one above, and provide the running time of your algorithm, with a brief justification.

2. [**50 points**] This question requires that you implement some methods for a class that represents a doubly-linked list. In this question, **both a beginMarker and endMarker are used**. You may assume an appropriate declared nested class `Node`.

(a) Implement the constructor.

(b) Implement the private helper method `addBefore` in the space shown below:

```
private void addBefore( Object x, Node p )
{




















}
```

(c) Implement both `addFirst` and `addLast` in the space shown below. You may assume code written by you in the previous part works.

```
public void addFirst( Object x )
{






}

public void addLast( Object x )
{






}
```

3. [**50 points**] Assume that you have a java.util.Map in which the keys are names of students (stored as a String), and for each student, the value is a java.util.List of courses (each course name is a String). Write a routine that computes the inverse map, in which the keys are the names of the courses, and the values are lists of enrolled students. The signature of your method is:

```
// In input Map
//     keys are String representing student name
//     values are List of String representing corresponding course
// In returned Map
//     keys are String representing course name
//     values are List of String representing corresponding students
public static Map inverseMap( Map m )
{
```

4. [**50 pts**] Method `getEvenElements` returns a `java.util.List` consisting of only the elements originally in the even indexes of a `java.util.List`. For instance, if the original list is `[3, 4, 8, 1, 5]`, then the returned list is `[3, 8, 5]`.

Implement `getEvenElements` **recursively**. You may write an additional private routine if you find that helpful. Your algorithm must be efficient in terms of Big-Oh, regardless of whether the `List` is an `ArrayList` or `LinkedList`.