

First Exam

CS 440 — Programming Languages

Fall, 2010

Friday, September 24, 2010 15:15–16:30

This is a **closed book** and **closed notes** exam.
You are **not** allowed to use calculators or computers during this exam.
Do **ALL** problems in this booklet. Read each question very carefully.
You may detach pages, but **you must return all pages of this exam.**

Name

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Problem	Points	Score
1	4	
2	4	
3	6	
4	4	
5	6	
6	6	
7	4	
8	6	
9	6	
10	4	
11	6	
12	6	
13	6	
14	4	
15	4	
16	4	
17	4	
18	6	
Total	90	
Percent	100	

1 Abstraction

Question 1) (4 points) What is an abstract data type?

Question 2) (4 points) What bad things can happen if you don't use abstract data types?

Question 3) (6 points)

You are the manager for two programming teams. You ask them to design a stack class for your software product's interface.

The first team noticed that the list class already included some extra methods like push and pop, so they simply copied the list class, naming it `stack`, and used it everywhere that they needed a stack. This approach saved a couple of weeks of programming time. The second team created a brand new stack class, and used an instance of the list as a private variable. They provided accessor methods for the methods they needed, but left out the rest of them. This drastically reduced the functionality of the stack class by leaving out most of the list methods.

Which team did the right thing, and why?

2 Lists

Question 4) (4 points)

Under what circumstances will an array implementation of a list give us better performance than a linked implementation?

Question 5) (6 points) Consider the following outline of a class definition.

```
public class List {  
    private class Node {  
        public int data;  
        public Node next;  
    }  
    Node first = null;  
    Node last = null;  
}
```

Assume that there are reasonable constructors, methods, and local variables defined. Write a **recursive** method that will return the sum of all the elements of this list. You may write a helper function if you want.

```
    public int sum(...)
```

Question 6) (6 points) Consider the following outline of a class definition.

```
public class List {  
    private class Node {  
        public int data;  
        public Node next;  
    }  
    Node first = null;  
    Node last = null;  
}
```

Assume that there are reasonable constructors, methods, and local variables defined. Write the code below for the `insertFront` method, which inserts an element at the beginning of the list. Make sure both `first` and `last` are set properly!

Question 7) (4 points)

What is the time complexity of this operation?

3 Memory

Question 8) (6 points) Consider the code below.

```
public class Foo {  
    Foo x;  
    int y;  
    Integer z;  
}  
  
Foo a = new Foo();  
Foo b = new Foo();  
  
a.x = a;  
a.y = 30;  
a.z = new Integer(30);  
  
b.x = a;  
b.y = a.y;  
b.z = new Integer(30);
```

Draw a memory diagram that illustrates the effect of the above code.

Question 9) (6 points) Now show the effect of the code

```
a.x = b;  
a.z = b.z;
```

Indicate which memory, if any, becomes garbage.

4 Stacks and Queues

Question 10) (4 points) What do the terms FIFO and LIFO mean? What data structures do they represent?

Question 11) (6 points)

What are the names of the three stack operations? Give their time complexities.

Question 12) (6 points)

What are the names of the three queue operations? Give their time complexities.

Question 13) (6 points)

Suppose you have a singly-linked `List` class, with a last pointer, like the one we've discussed in class. Suppose also that we have used this as our implementation for a queue. Write the code for the `dequeue` method.

5 Iterators

Question 14) (4 points)

What are the operations that all iterators must provide?

Question 15) (4 points)

What is the advantage of the iterator model over the cursor model?

6 Doubly Linked Lists

Question 16) (4 points)

Give one operation that is faster for doubly-linked lists than for singly-linked lists, and one operation that is the same speed for both.

Question 17) (4 points)

Making reasonable assumptions about constructor and member variable names, write a method `public int sum()` that finds the sum of a doubly-linked list.

Be sure to indicate whether or not you are using sentinels.

Question 18) (6 points)

Making reasonable assumptions about constructor and member variable names, write a method `public void delete(Node n)` that deletes a node n from a doubly-linked list. You are guaranteed to have a valid node. To receive credit, your answer **must** run in $\mathcal{O}(1)$ time.

Be sure to indicate whether or not you are using sentinels.