Midterm 1 Review Document Solution

CS 61B Spring 2017

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Introduction

This document is meant to provide you supplementary practice questions for the upcoming midterm. It reflects all material that you will have already seen in labs and lecture. Do not use this as a “be all end all” guide! It is still highly recommended that you review previous and external course material.

For example, I suggest that you do many practice midterms from previous semesters. Use the midterms a heuristic for your knowledge of the material, then use the lab guides and textbook to relearn the material.

Finally, make sure you don’t stress! This class is hard and will only be made harder if you stress yourself out. But you smart, you loyal #blessup. Ask lots of questions and let us the TA’s help you (believe me when I say we want you guys to succeed).

If you find yourself beginning to panic, simply pause, breathe, and believe. In the off chance you don’t believe in yourself, then believe in me who believes in you.

Introduction

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Know Your Java

This Code Sucks!

This code sucks… no seriously some of the below code examples are broken. For this question, we will be looking at the following classes.

```java
public class A {
    private int valA = 2;
    public void f() {
        this.g();
    }
    public void g() {
        System.out.println("A:" + valA);
    }
    public int h() {
        return valA;
    }
    public static A createA() {
        return new A();
    }
}
```

```java
public class C extends B {
    private int valC = 42;
    public void f() {
        this.g();
    }
}
```

```java
public class B extends A {
    private int valB = 15;
    protected int value = 1337;
    public void g() {
        System.out.println("h:" + h() + " z:" + valB);
    }
    public void banana() {
        System.out.println("no");
    }
}
```

Beneath are a number of coding examples. Next to each, determine if the code can run. If it can, write down the output, else state what type of error (compile-time vs runtime) is thrown and for what reason.

`// to be placed in class A` `public static void main(String[] args) {` `    A this = new A();` `    this.g();` `}`	Compile-time error. Cannot assign to `this`.
`// to be placed in class A` `public static void main(String[] args) {` `    A thing = this.createA();` `    thing.f();` `}`	While this is valid in Java, `createA` is a static method. It is misleading to access it through an instance.
`// to be placed in class A` `// what is this?` `public A(int valA) {` `    this.valA = valA;` `}`	This is a constructor. Since we've explicitly defined a constructor, Java no longer provides the default constructor which breaks `createA`.
`// to be placed in class A` `public static void main(String[] args) {` `    A thingC = new C();` `    System.out.println(thingC.valC);` `}`	Compile-time error. The static type of `thingC` is A and A does not have a `valC` field.
`// to be placed in class A` `public static void main(String[] args) {` `    A thingB = new B();` `    thingB.banana();` `}`	Compile-time error. The static type of `thingB` is A and A does not have a `banana` method.
`// to be placed in class A` `public static void main(String[] args) {` `    A thingB = new B();` `    thingB.g();` `}`	`h:2 z:15`

`// to be placed in class B` `public static void main(String[] args) {` `    A thingB = new B();` `    System.out.println(thingB.valA);` `}`	Compile-time error. `valA` is a private field in A.
`// to be placed in class B` `public static void main(String[] args) {` `    B thingB = new B();` `    System.out.println(thingB.h());` `}`	2
`// to be placed in class B` `public static void main(String[] args) {` `    System.out.println(this.valB);` `}`	Compile-time error. Cannot access an instance variable from a static context.
`// to be placed in class B` `public static void main(String[] args) {` `    System.out.println(B.valB);` `}`	Compile-time error. `valB` is an instance variable.
`// to be placed in class C` `public static void main(String[] args) {` `    C thingC = new C();` `    System.out.println(thingC.value);` `}`	1337
`// to be placed in class C` `public static void main(String[] args) {` `    C thingC = new A();` `    System.out.println(thingC.valC);` `}`	Compile-time error. A is not a subtype of C.

What Type is This?

Look at the code blocks below. In the box besides it, write down the highlighted variables static and dynamic type and then write down what the statement would execute to.

`` public class Main { public static void method(B arg1) { System.out.println(arg1.g()); } public static void main(String[] args) { C thingC = new C(); method(thingC); } } ```	Static: B Dynamic: C
`` public class Main { public static void method(A arg1) { C arg2 = (C) arg1; arg2.f(); } public static void main(String[] args) { C thingC = new C(); method(thingC); } } ```	Static: C Dynamic: C
`` public class Main { public static void main(String[] args) { A thingC = new C(); thingC.f(); } } ```	Static: A Dynamic: C
`` public class Main { public static void main(String[] args) { A thing = new B(); B thingy = (B) thing; thingy.banana(); } } ```	Static: B Dynamic: B

Functions as Objects

Unlike Python, Java doesn't treat functions as first class objects. This means that we can't simply pass methods into each other in a functional manner. However, we can employ object orientation to get around this. Consider the following class

```
/** IntFunction is an object representing functions that return ints. */
public class IntFunction {
    // an instance variable that represents an incoming argument.
    int arg;
    public void setArg(int arg) {
        this.arg = arg;
    }
    public int apply() {
        return -1;
    }
}
```

We can consider `IntFunction` as a base class for all functions that accepts an int and returns an int. The actual functionality of the method we wish to represent would go into the instance method apply. By default, apply returns -1. To produce more complicated behavior (such as methods that accept arguments) we can simply extend `IntFunction`. Consider `SquareFunction`, a method that squares an input argument.

```
/** SquareFunction represents a functions that squares ints. */
public class SquareFunction extends IntFunction {
    public int apply() {
        return arg * arg;
    }
}
```

And finally, we can now apply it in a functional manner!

```
public static void main(String[] args) {
    int[] inputs = {1, 2, 3, 4, 5};
    SquareFunction sf = new SquareFunction();
    for (int i = 0; i < inputs.length; i += 1) {
        sf.setArg(inputs[i]);
        inputs[i] = sf.apply();
    }
    // now inputs = {1, 4, 9, 16, 25};
}
```

1) Define an object representing the `isMultipleOf` function. That is your object should be able to take in an integers and N, returning the number if it is a multiple of N else returning -1.

```
public class MultipleFunction extends IntFunction {
    // what do I need as instance variables?
    private int mult;

    // wait there's no return type...
    public MultipleFunction(int mult) {
        this.mult = mult;
    }

    public void setMult(int mult) {
        this.mult = mult;
    }

    public int apply() {
        if (arg % mult == 0) {
            return arg;
        }
        return -1;
    }
}
```

2) Define the map function in this main class. The map function should take in any functional object and apply it to each element of an int list. **NOTE** for easy-mode write map iteratively, for *hard-mode* write map recursively

```
public class Main {

    public static void easyMap(IntList list, IntFunction f) {
        for (; list != null; list = list.rest) {
            f.setArg(list.first);
            list.first = f.apply();
        }
    }

    public static void hardMap(IntList list, IntFunction f) {
        hardMapHelper(list, f);
    }

    private static void hardMapHelper(IntList list, IntFunction f) {
        if (list != null) {
            f.setArg(list.first);
            list.first = f.apply();
            hardMapHelper(list.rest, f);
        }
    }
}
```

DBCCCCCCCCCCC

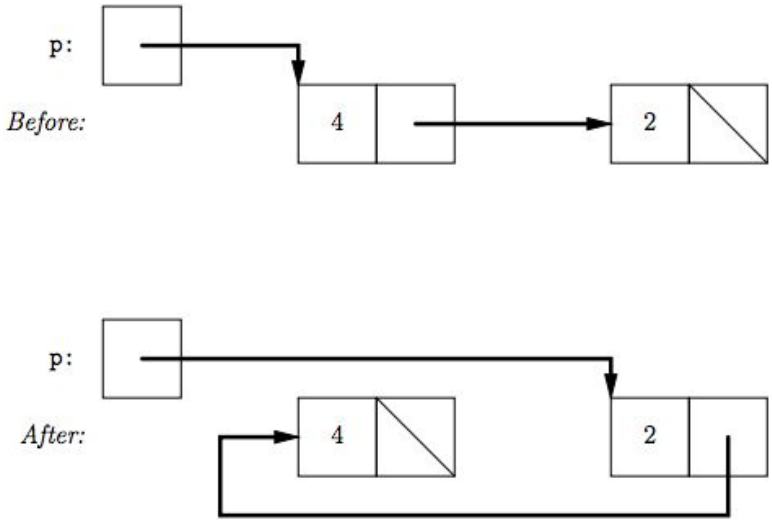
Don’t be clueless and read the documentation below! Then write the corresponding code that implements the functionality.

```
public class DBC {

    public static void main(String[] args) {
        /* 2. Declare a variable named "a" of type int. */
        int a;

        /* 3. Assign the value 3 to a.*/
        a = 3;

        /* 4. Declare another variable named b of type
         * int, initializing with value 5. */
        int b = 5;

        /* 5. Declare a variable named c and initialize
         * it with the result of invoking the
         * sum method on a and b. */
        int c = a + b;

        /* 6. Declare a variable named chaka, which is
         * an array of bytes, with size 7. */
        byte[] chaka = new byte[7];

        /* 7. Declare a variable named khan, which is
         * an array of longs, with contents 1, 2, 3, 4,
         * 5. */
        long[] khan = {1, 2, 3, 4, 5};

        /* 8. Set khan's second item (index 1) as chaka's
         * last item. */
        khan[1] = chaka[chaka.length - 1];

        /* 9. You are given the following array with unknown
         * size. Write a for-loop that prints all elements
         * IN REVERSE */
        int[] someArray = ...;
        for (int i = someArray.length - 1; i >= 0; i -= 1) {
            System.out.print(someArray[i]);
        }
```

```
        /* 10. You are given an integer n. Using a for
         * loop, create an n by n identity matrix called
         * eye, where all diagonal entries are set to 1
         * and other entries are set to 0 from top left
         * to bottom right. You can represent the matrix
         * as an array of int arrays. Hint: the default
         * value for int is 0. */
        int n = ...;
        int[][] eye = new int[n][n];
        for (int i = 0; i < n; i += 1) {
            eye[i][i] = 1;
        }
    }
}
```

Pox and Bointers

The before picture shows the state of an `IntList` object and one local variable. In the lines provided, write the Java code statements that transforms the before picture to the after, subject to the following restrictions. (1) do not modify the `first` instance variable and (2) do not introduce any new variables.




```
p.rest.rest = p;
p = p.rest;
p.rest.rest = null;
```

Arrays

Easy Mode

These questions test basic understanding of manipulating arrays and such.

Hella Deep Copy Given a 3D array, make a deep copy of the array. That is return a new 3D array that contains the same elements as the previous. Remember the array may be ragged!

```
public static int[][][] hellaDeepCopy(int[][][] array) {
    int[][][] copy = new int[array.length][][];
    for (int i = 0; i < array.length; i += 1) {
        copy[i] = new int[array[i].length][];
        for (int j = 0; j < array[i].length; j += 1) {
            copy[i][j] = new int[array[i][j].length];
            for (int k = 0; k < array[i][j].length; k += 1) {
                copy[i][j][k] = array[i][j][k];
            }
        }
    }
    return copy;
}
```

Print All Given a 2D array, print all the elements. Remember it's possible that the array is ragged! Make sure to line break each int[] iterated through.

```
public static void printAll(int[][] array) {
    for (int i = 0; i < array.length; i += 1) {
        for (int j = 0; j < array[i].length; j += 1) {
            System.out.print(array[i][j] + " ");
        }
        System.out.println();
    }
}
```

Medium Mode

This section provides questions that should match your understanding of arrays after labs.

Iterative Fibonacci Array Given a number *N* return an array of arrays such that the ith array contains all fibonacci numbers up to the ith one. For example if the *N*=4, the return result would be `[[1], [1, 1], [1, 1, 2], [1, 1, 2, 3]]`.

```
public static int[][] fibonacciArray(int n) {
    int[][] result = new int[n][];
    for (int i = 0; i < n; i += 1) {
        result[i] = new int[i + 1];
        for (int j = 0; j <= i; j += 1) {
            if (j == 0 || j == 1) {
                result[i][j] = 1;
            } else {
                result[i][j] = result[i][j - 1] + result[i][j - 2];
            }
        }
    }
    return result;
}
```

IntList to Array convert an `IntList` to an array.

```
// assume that IntList has a size() method returning the length of the
list
public static int[] toArray(IntList list) {
    int[] result = new int[list.size()];
    toArrayHelper(0, result, list);
    return result;
}

public static void toArrayHelper(int index, int[] nList, IntList list) {
    if (list == null) {
        return;
    } else {
        nList[index] = list.first;
        toArrayHelper(index + 1, nList, list.rest);
    }
}
```

Hard Mode

This last section contains non-trivial, purposefully obfuscated applications of arrays. Try your best!

Recursive Fibonacci Array Do the fibonacci array question again, but recursively!

```
public static int[][] fibonacciArray(int n) {
    int[][] results = new int[n][];
    fibArrayHelper1(results, n - 1);
    return results;
}

public static void fibArrayHelper1(int[][] something, int k) {
    if (k >= 0) {
        something[k] = new int[k + 1];
        fibArrayHelper2(something[k], k);
        fibArrayHelper1(something, k - 1);
    }
}

public static void fibArrayHelper2(int[] array, int k) {
    if (k == 0) {
        array[index] = 1;
    } else if (k == 1) {
        fibArrayHelper2(array, k - 1);
        array[index] = 1;
    } else {
        fibArrayHelper2(array, k - 1);
        fibArrayHelper2(array, k - 2);
        array[index] = array[k - 1] + array[k - 2];
    }
}
```

Linked Lists

Easy Mode

The next couple of questions will have some linked list questions. The first few will focus on basic understanding of linked lists.

Deep Copy given an `IntList`, return an exact copy of that linked list.

```
public static IntList deepCopy(IntList list) {
    if (list == null) {
        return null;
    } else {
        return new IntList(list.first, deepCopy(list.rest));
    }
}
```

Find Max Given a `IntList` return the max element of that list.

```
public static int maxElement(IntList list) {
    if (list == null) {
        return -1;
    }
    int max = list.first;
    while (list != null) {
        list = list.rest;
        if (list.first > max) {
            max = list.first;
        }
    }
    return max;
}
```

Medium Mode

A few questions that should match on par understanding after lab and practice

Copy Odd Given an `IntList`, non-destructively remove all even elements.

```
public static IntList copyOdd(IntList list) {
    if (list == null) {
        return null;
    } else if (list.first % 2 == 0) {
        return new IntList(list.first, copyOdd(list.rest));
    } else {
        return copyOdd(list.rest);
    }
}
```

Abstract Interfaces

Easy Mode

Warm-up Questions

1) What are the differences between abstract classes and interfaces? Why might we wish to use one over the other?

   Abstract classes use the `extends` keyword; a class can only extend one abstract class; and abstract classes are generally used for providing partial implementations.

   Interfaces use the `implements` keyword; a class can implement many interfaces; and interfaces are generally used to provide a contract of methods.

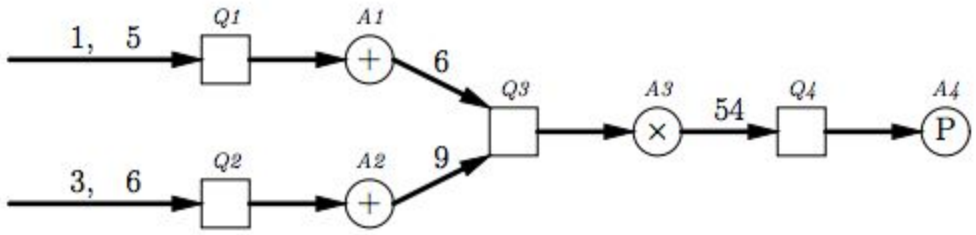
2) Why is it okay to write `List<T> list = new ArrayList<>()` but not `ArrayList<T> list = new List<T>()`?

   `List<T>` is an interface which cannot be instantiated. We can declare the static type, `List<T>`, as an interface but we need to provide a concrete implementation for the actual object, `ArrayList<T>`.

Medium Mode

Computation Network

A simple computational network is composed of *value queues* (represented by squares in the example below) and *computation nodes* (circles in the example below). Both value queues and computation nodes have inputs and outputs. Integer values come into each value queue, which accumulates them until the computation node on its output indicates there are enough values for its computation. At that point, the value queue sends its accumulated values to its computation node, which computes a value that is sent to another value queue. In the example below, '+' nodes wait for two inputs and compute their sum; '×' nodes wait for two inputs and compute their product; and 'P' nodes wait for one input and print it (producing nothing):



We'll represent value queues with the class *ValueQueue* and describe computations with an interface called *Computation*. Here is *ValueQueue*:

```
import java.util.ArrayList;

public class ValueQueue {

    private Computation sink;
    private ArrayList<Integer> queue = new ArrayList<>();

    public void attach(Computation sink) {
        this.sink = sink;
    }

    public void accept(Integer value) {
        queue.add(value);
        if (sink.enabled(queue.size())) {
            sink.consume(queue);
            queue.clear();
        }
    }
}
```

And the code to set up the above network and inputs.

```
ValueQueue Q1 = new ValueQueue(), Q2 = new ValueQueue()
           Q3 = new ValueQueue(), Q4 = new ValueQueue();
Computation A1 = new Adder(Q3), A2 = new Adder(Q3),
           A3 = new Multiplier(Q4), A4 = new Printer();
Q1.attach(A1); Q2.attach(A2);
Q3.attach(A3); Q4.attach(A4);

Q1.accept(1); Q2.accept(3);
Q2.accept(6); Q1.accept(5);
```

Working backwards from the code, fill in a suitable definition for the Computation interface and the Adder class

```
public interface Computation {
    void consume(ArrayList<Integer> list);
    boolean enabled(int length);
}

public class Adder {
    private ValueQueue q;

    public Adder(ValueQueue q) {
        this.q = q;
    }

    public boolean enabled(int length) {
       return length >= 2;
    }

    public void consume(ArrayList<Integer> list) {
        int value = list.remove(0) + list.remove(1);
        q.accept(value);
    }
}
```


There is no need
to be upset.