

CS 2420: Introduction to Algorithms and Data Structures

Midterm 1 (SAMPLE – Make your own key)

Do not limit your studying to finding the answers to these sample questions.

The test is closed-book, closed-notes. In addition, no laptops, calculators, cell phones, or other electronic devices are allowed. The test is 80 points in 80 minutes.

1. **(4 points)** Consider the following Java code.

```
public class MyClass {
    public static void doSomething(char c, float[] f) {
        ? ? ?
    }

    public static void main(String[] args) {
        char letter = 'a';
        float[] arr = {1.2, 3.4, 5.6, 7.8};
        doSomething(letter, arr);
        System.out.println(letter);
        System.out.println(f[0]);
    }
}
```

Which of the following is *definitely* true? *Fill in one or more choices.*

- ☐ The value printed in the penultimate statement of `main` is 'a'.
- ☐ The value printed in the penultimate statement of `main` is not 'a'.
- ☐ The value printed in the last statement of `main` is 1.2.
- ☐ The value printed in the last statement of `main` is not 1.2.

2. **(4 points)** Is the following statement true or false? Justify your answer.

All Java interfaces are abstract classes, but not all abstract classes are Java interfaces.

3. **(12 points)** Given the following class definition fragments and class instantiations, complete the table below. Assume that the methods shown here do not appear in any other classes. (E.g., The `Restaurant` class does not define a `toString` method.)

```
class Building { public Point getLocation() ... }
class Restaurant extends Building { public int getSeatCount() ... }
class Lab extends Building { public String toString() ... }
class Diner extends Restaurant { public boolean equals(Object other) ... }
```

```
Lab l = new Lab();
Restaurant r = new Diner();
Building b = l;
Object o = r;
```

In each blank cell, indicate what would happen if the method in each column is invoked with the object `obj` in each row. Choose (only one) from the following.

- compiler error
- runtime error (i.e., an exception is thrown)
- X , where X is the class from which the method is called

The first row has been done for you, as a example.

obj	obj.getLocation()	obj.getSeatCount()	obj.toString()	obj.equals(obj)
b	Building	compiler error	Lab	Object
l				
o				
r				

4. **(4 points)** What is the running time of the following loop nest?

```
for(int i = 0; i < N+N; i++)
    for(int j = N; j > 0; j--)
        System.out.println("hello world");
```

Fill in exactly one choice.

- ☐ logarithmic
- ☐ linear
- ☐ $N \log N$
- ☐ quadratic
- ☐ cubic

5. **(20 points)** Write, test, and analyze a generic method for finding and returning the smallest item in an array.

(a) Give the method definition here. (Make sure that your hand-written code has proper letter cases and indentation.)

(b) Briefly describe how you would test the method for correctness.

(c) Which of the following is the running time of your method in the worst case? *Fill in exactly one choice.*

- ☐ logarithmic
- ☐ linear
- ☐ $N \log N$
- ☐ quadratic

(d) Which of the following is the running time of your method in the average case? *Fill in exactly one choice.*

- ☐ logarithmic
- ☐ linear
- ☐ $N \log N$
- ☐ quadratic

6. **(6 points)** Carefully explain to a new Java programmer why all sorting methods that have a basic array as a parameter also have a `void` return type. (Use complete sentences with correct grammar and spelling. Make significant and relevant points — avoid trivial, terse answers.)

7. **(6 points)** Consider the following recursive method `foo`.

```
public static int foo(int x) throws Exception {  
    if(x <= 0)  
        throw new Exception("Input must be positive.");  
    if(x == 1)  
        return 1;  
    return foo(x);  
}
```

Which of the following is true of `foo`? *Fill in exactly one choice.*

- ☐ `foo` is correct and does not do redundant work
- ☐ `foo` is correct but is inefficient due to redundant work
- ☐ `foo` is incorrect

If you did not select the first choice, briefly describe how to modify `foo` such that it is true.

8. **(8 points)** Suppose that you have a friend who is new to programming and learning a language unfamiliar to you. She wants your advice on how to sort a list of items for which the ordering is unknown. Provide your friend with a recommendation on which sorting algorithm to use and give the reason(s) for your recommendation. (Use complete sentences with correct grammar and spelling. Make significant and relevant points — avoid trivial, terse answers.)

9. **(4 points)** Your tool for plotting running times is not working! So, you collected running times and applied the *check analysis* technique of computing $T(N)/F(N)$ as N increases.

N	$T(N)$	$T(N)/\log N$	$T(N)/N$	$T(N)/N \log N$	$T(N)/N^2$
2000	$3397 * 10^2$	$3098 * 10^1$	$1698 * 10^{-1}$	$1549 * 10^{-2}$	$8492 * 10^{-5}$
4000	$6739 * 10^2$	$5632 * 10^1$	$1685 * 10^{-1}$	$1408 * 10^{-2}$	$4212 * 10^{-5}$
8000	$1354 * 10^3$	$1044 * 10^2$	$1692 * 10^{-1}$	$1305 * 10^{-2}$	$2115 * 10^{-5}$
16000	$2696 * 10^3$	$1931 * 10^2$	$1685 * 10^{-1}$	$1207 * 10^{-2}$	$1053 * 10^{-5}$
32000	$5398 * 10^3$	$3607 * 10^2$	$1687 * 10^{-1}$	$1127 * 10^{-2}$	$5272 * 10^{-6}$
64000	$1077 * 10^4$	$6748 * 10^2$	$1683 * 10^{-1}$	$1054 * 10^{-2}$	$1415 * 10^{-6}$

By examining the results above, select the growth rate that is the best match. *Fill in exactly one choice.*

- ☐ constant
 ☐ logarithmic
☐ linear
 ☐ $N \log N$
☐ quadratic

10. **(12 points)** Consider a singly-linked list containing the following animals (in this order): *cow*, *dog*, *duck*, *cat*, and *canary*.
- (a) Draw a picture of the linked list. Be sure to include a reference to beginning of the list called **head**.
 - (b) Suppose that a reference called **prev** points to the node containing *dog*. Show how to remove the node containing *duck*. Draw a picture and give the pseudocode.
 - (c) Suppose that a reference called **prev** points to the node containing *cat*. Show how to insert a node containing *moose* between *cat* and *canary*. Draw a picture and give the pseudocode.
 - (d) What is a “header node”? Defend the existence or absence of such a node in the linked list you have drawn above.