COS 126	General Computer Science	Spring 2009

Exam 2

This test has 9 questions worth a total of 50 points. You have 50 minutes. The exam is closed book, except that you are allowed to use a one page cheatsheet. No calculators or other electronic devices are permitted. Give your answers and show your work in the space provided. **Write out and sign the Honor Code pledge before turning in the test.**

"I pledge my honor that I have not violated the Honor Code during this examination."

`Signature`

Name:

NetID:

Problem	Score
0	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

P01	TTh 1:30	Will
P01A	TTh 1:30	Rob
P01B	TTh 1:30	Aditya
P01C	TTh 1:30	Michael
P02	TTh 2:30	Will
P03	TTh 3:30	Rob
P04	TTh 7:30	Chris
P05	WF 10	JP
P06	WF 1:30	Chris
P06A	WF 1:30	Thomas
P06B	WF 1:30	Donna
P06C	WF 1:30	Michael

0. **Miscellaneous. (1 point)**

   (a) Write your name and Princeton NetID in the space provided on the front of the exam, and circle your precept number.

   (b) Write and sign the honor code on the front of the exam.

1. **Data types. (6 points)**

   (a) Define what is a *data type*.

   A set of ____________________ and ____________________

   on those ____________________.

   (b) For each description on the left, find the *best* matching modifier on the right. You may use a choice more than once or not at all.

___	Hides the instance variable from code in other files.	A. `private`
___	Hides the method from code in other files.	B. `public`
___	Hides the subclass from code in other files.	C. `final`
___	Exposes the API method to code in other files.	D. `static`
___	Prevents the value of the instance variable from being changed once initialized.	E. none of the above

   (c) List two compelling reasons why experienced programmers declare their instance variables to be `private`.

   -
   -

2. **Scientific computation. (4 points)**

You need to compute the great-circle distance between a pair of points (x_1, y_1) and (x_2, y_2). Unfortunately, your Java implementation of the mathematically-exact formula from Assignment 1 yields inaccurate results (up to about .5% error) when the two points are very close.

$$d = 60 \arccos(\sin x_1 \sin x_2 + \cos x_1 \cos x_2 \cos(y_1 - y_2))$$

How should you proceed? Circle the best answer.

I. Explain to your boss that your formula is mathematically accurate, so any inaccuracies are the computer's fault.

II. Explain to your boss that computing the great-circle distance is an ill-conditioned problem, so there is no hope of finding a more accurate formula.

III. Find (or design) an alternate formula for computing the great circle distance that is numerically stable.

3. **Regular expressions. (5 points)**

You are searching for genes which have the following four properties:

- Composed of a sequence of nucleotides (`A`, `C`, `T`, or `G`).
- Starts with the nucleotide triplet `ATG`.
- Consists of a multiple of 3 nucleotides.
- Ends with one of the following nucleotide triplets `TAG`, `TAA`, or `TTG`.

Complete the program `GeneChecker.java` so that it takes a `String` as a command-line argument and prints `true` or `false` depending on whether that string satisfies the conditions above.

```
public class GeneChecker {

   public static void main(String[] args) {


      String re =


      System.out.println(args[0].matches(re));


   }

}
```

4. **Pass-by-value and references. (6 points)**

```
public class PassByValue {

    public static void f(int x, int[] y, String z, Stack<String> s) {
        x = 1111;
        y[0] = 2222;
        y = new int[5];
        y[0] = 4444;
        z = "5555";
        s.push("9999");
    }

    public static void main(String[] args) {
        int x = 1;
        int[] y = { 2, 3, 4 };
        String z = "5";
        Stack<String> s = new Stack<String>();
        s.push("6");
        s.push("7");
        f(x, y, z, s);
        z = z.replaceAll("5", "6");
        z.replaceAll("6", "8");
        System.out.println(x);
        System.out.println(y[0]);
        System.out.println(z);
        System.out.println(s.pop());
    }
}
```

What is the output of the program above? Circle your answer.

5. **Analysis of algorithms. (6 points)**

(a) Professor Quring proposes the following recursive algorithm for sorting an array of N real numbers in ascending order.

```
public static void sort(double[] a) {
    sort(a, 0, a.length-1);
}

public static void sort(double[] a, int lo, int hi) {
    if (lo >= hi) return;
    sort(a, lo, hi-1);
    if (a[hi] < a[hi-1]) {
        double temp = a[hi];
        a[hi] = a[hi-1];
        a[hi-1] = temp;
        sort(a, lo, hi-1);
    }
}
```

To analyze its running time, the professor performs the following experiments on arrays of random real numbers.

N	time (sec)
1,000	0.75
2,000	6.00
3,000	20.25
4,000	48.00
5,000	93.75
6,000	162.00

Predict (within 10%) how long it will take (in seconds) to sort $10,000$ random real numbers.

(b) Give two compelling reasons why you might prefer to implement an algorithm that runs in time proportional to N^2 instead of one that runs in time proportional to $N \log N$.

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6. **Stacks and queues. (8 points)**

Complete the following implementation of queue implemented with a linked list.

```
public class QueueOfStrings {
    private Node first = null;   // least-recently added
    private Node last = null;    // most-recently added

    private class Node {
        private String item;
        private Node next;
    }

    // is the queue empty?
    public boolean isEmpty() {
        return first == null;
    }

    // remove and return the least recently added item
    public String dequeue() {
        if (isEmpty()) throw new RuntimeException("Queue underflow");








    }

    // add a new item to the queue
    public void enqueue(String item) {











    }
}
```

7. **Theory of computation. (8 points)**

   Extra! Extra! Read all about it! The following are (mostly fictitious) headlines, past and future. Some of them could possibly be attached to true stories (P), others are absolutely impossible (I). Classify the headlines accordingly.

___ Princeton computer science professor proves P = NP; existence of polynomial-time algorithm for factoring (and breaking the RSA cryptosystem) remains an open question.

___ Symantec Releases 100% guaranteed general-purpose virus detector.

___ Princeton student solves SAT instances that have thousands of variables in their senior thesis.

___ Princeton graduate student publishes polynomial-time algorithm for factoring integers—banking industry in an uproar.

___ COS 126 student proves that $P = NP$ by experimentally verifying that the smallest-insertion heuristic runs in N^2 time.

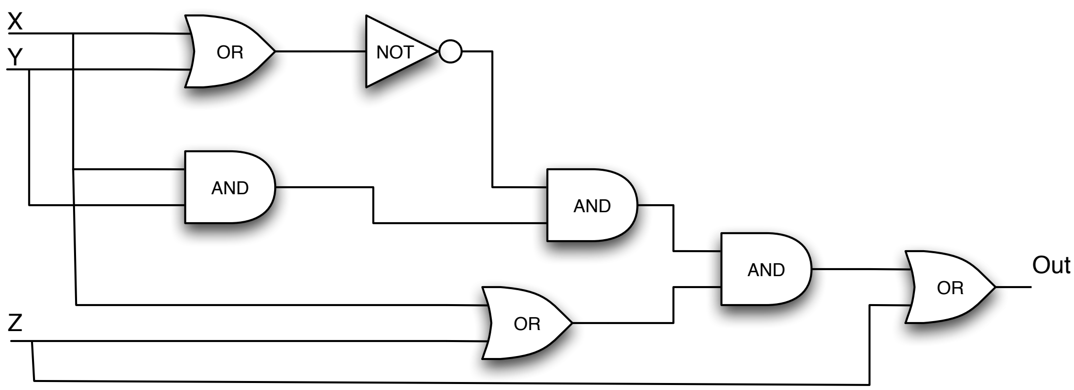
___ COS 126 preceptor develops software to decide program equivalence—claims it will completely automate grading of programs.

___ Physicist identifies a search problem that can be solved in polynomial time on a classical computer, but not on a Turing machine.

___ COS 126 student finds provably-optimal TSP tour for `tsp1000.txt`.

8. **Circuits. (6 points)**

Consider the following circuit.



(a) What boolean formula does the above circuit implement?

i. $(X + Y)(XY) + Z$

ii. $(X + Y)'(XY) + Z$

iii. $(X + Y)'(XY)(Y + Z) + X$

iv. $(X + Y)'(XY)(Z + X) + Z$

v. $(X + Y)'(XY)'(Z + X) + Z$

vi. none of the above

(b) Write the truth table for all possible input combinations of X, Y, and Z.

X	Y	Z	f
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

(c) Write a simplified boolean formula that implements the above circuit.