COS 126 **General Computer Science** **Spring 2012**

Written Exam 2

This test has 9 questions, weighted as indicated. The exam is closed book, except that you are allowed to use a one-page (doublesided) cheatsheet handwritten by you. 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

Problem	Score
0	/1
1	/8
2	/6
3	/10
4	/7
Sub 1	

Problem	Score
5	/10
6	/3
7	/5
8	/10
Sub 2	

Total	

Name:

NetID:

Lecture:

L01	10:00	
L02	11:00	

Precept: (circle your lecture AND precept)

P01	12:30	Christopher Moretti
P01A	12:30	Donna Gabai
P01B	12:30	Jude Nelson
P02	1:30	Chris Miller
P02A	1:30	Donna Gabai
P02B	1:30	Maia Ginsburg
P02C	1:30	Thiago Pereira
P03	2:30	Chris Miller
P03A	2:30	Christopher Moretti
P04	3:30	Maia Ginsburg
P04A	3:30	Dom Kao
P05	7:30	Adi Dror
P06	10:00	Deep Ghosh
P07	1:30	Ian Davey
P07A	1:30	Jude Nelson
P07B	1:30	Dmitry Drutskoy
P08	12:30	Deep Ghosh
P08A	12:30	Mark Browning

0. **Cover Page.** Write your name and netid, select your lecture and precept sections, and write out the honor code on the cover (now!) and sign it when you complete the test.

1. **Regular Expressions.** What regular expression will match U.S. street addresses? Assume that street numbers never start with 0, that street names can have multiple capitalized words and may have just one character, that all end with "Street" or "Road" or "Avenue", and that one or more whitespace characters will separate the parts. Use character range notation: for example, [b-n] will match any lower-case letter alphabetically between b and n, and [2-4] will match 2, 3, or 4. Remember that \s matches any whitespace character.

examples

match	don't match
25 Spring Garden Street	0034 Main Street
6666 N Street	34 MAIN Street
2 Pleasant Avenue	2 loVeLy Road
444 Pheasant Hop Road	44 Happy Hollow Rd.

Circle the letter for each RE below that matches the street address model above. (Circle f if none match.)

For each RE that you do NOT circle, underline one part of the RE which does not match the desired model.

a. `[0-9]*\s[A-Z][a-z]\s(Street | Road | Avenue)`

b. `[1-9][0-9]+\s+([A-Z][a-z]+\s+)+(Street | Road | Avenue)`

c. `[1-9][0-9]*\s+([A-Z][a-z]*\s+)+(Street | Road | Avenue)`

d. `[1-9][0-9]*\s+([A-Z][a-z]+\s*)+(Street | Road | Avenue)`

e. `[1-9]+\s+([A-Z][a-z]*\s+)+(Street | Road | Avenue)`

f. none of the above.

Counterexamples:

a. `[0-9]*` would allow a street number beginning with 0, or no number at all. `\s` requires exactly one space. `[a-z]` requires exactly 1 lower-case character in the street name.

b. `[0-9]+` requires at least a second digit in the street number. `[a-z]+` requires at least one lower-case character in the street name.

d. `[a-z]+` requires at least one lower-case character in the street name. `\s*` allows no space between the street name and street suffix.

e. `[1-9]+` disallows any 0's in the street number.

2. **List.** Consider the following buggy linked list code:

```
1: public class List {
2:
3:    private Node start; // pointer to the beginning of the list
4:
5:    private class Node {
6:       int data;
7:       Node next;
8:       Node (int x, Node y) {data=x; next=y;}
9:    }
10:
11:   // create a new linked list of 7 nodes.
12:   public List() {
13:      Node node7 = new Node(7, null);
14:      Node node6 = new Node(6, node7);
15:      Node node5 = new Node(5, node6);
16:      Node node4 = new Node(4, node5);
17:      Node node3 = new Node(3, node4);
18:      Node node2 = new Node(2, node3);
19:      start = new Node(1, node2);
20:    }
21:
22:   // show selected items from the linked list.
23:   public void show() {
24:      Node p = start;
25:      while (p != null) {
26:         p.next = p.next.next;
27:         System.out.print(p.data);
28:         p = p.next;
29:      }
30:   }
31:
32:   public static void main(String[] args) {
33:      List list = new List();
34:      list.show();
35:      System.out.println();
36:      System.out.println("Done!");
37:   }
38:}
```

What is the output when `java List` is run?

```
135Exception in thread "main" java.lang.NullPointerException
at List.show(List.java:26)
at List.main(List.java:34)
```

3. **ADT.** Consider the following two files: `AudioPlayer.java` and `TestAudioPlayer.java`. The first is a class that maintains and plays a list of songs. The second is a program that uses these objects.

```
1: public class AudioPlayer {
2:   // table of key->value mappings. a song title -> its popularity count.
3:   private ST<String, Integer> st;
4:
5:   // create empty symbol table
6:   public AudioPlayer() { st = new ST<String, Integer>(); }
7:
8:   // add new song to symbol table or add to count if already there
9:   public void addSong(String title) {
10:    if (!st.contains(title)) st.put(title, 1);
11:    else {
12:      int count = st.get(title) + 1;
13:      st.put(title, count);
14:    }
15:  }
16:
17:  // play a song in symbol table and print its title and popularity count
18:  public void play(String title) {
19:    if (!st.contains(title)) return;
20:    System.out.println("Song: " + title);
21:    System.out.println("Count: " + st.get(title));
22:    addSong(title);
23:    StdAudio.play(title + ".wav");  // assume we can have blanks in filenames
24:  }
25:
26:  // play and print all songs
27:  public void playAll() {
28:    for (String title : st)
29:      play(title);
30:  }
31:}
```

```
1: public class TestAudioPlayer {
2:   public static void main(String[] args) {
3:     AudioPlayer popularlist = new AudioPlayer();
4:     AudioPlayer backgroundlist = new AudioPlayer();
5:     popularlist.addSong("Hard Work");
6:     popularlist.addSong("Too Close");
7:     backgroundlist.addSong("Wild One");
8:     backgroundlist.addSong("Too Close");
9:     backgroundlist.playAll();
10:
11:  }
12:}
```

(A.) Write the printed output when `java TestAudioPlayer` is run. (Assume `ST` iteration order is alphabetical.)

```
Song: Too Close
Count: 1
Song: Wild One
Count: 1
```

(B.) Suppose `main` in `TestAudioPlayer` had this code on line 10:

```
int i = backgroundlist.st.get("Hard Work");
```

Why would this cause a compile error?

`st` is a private instance variable in `AudioPlayer.java` and is not visible to the client `TestAudioPlayer`.

(C.) Suppose `st` were declared as `static`. What would the answer to (A.) be?

If `st` were declared as `static`, there would only be one table shared across all instances:

```
Song: Hard Work
Count: 1
Song: Too Close
Count: 2
Song: Wild One
Count: 1
```

(D.) The class `AudioPlayer` is immutable. TRUE or FALSE (circle your answer)

(E.) Each of the following occurs one or more times in the code above. Give the class name and line number(s) for ONE example of each occurence (you may abbreviate the class names as AP and TAP).

client program: TAP 1-12.

instance variable declaration: AP 3.

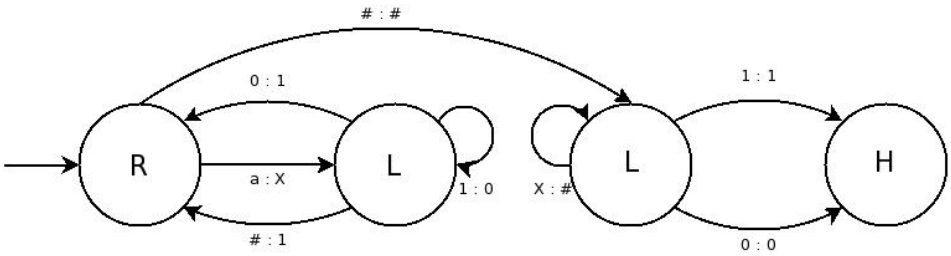
constructor signature: AP 6.

object creation: AP 6. TAP 3, 4. Implicit object creation on AP 10, 13, 20, 21, 23.

primitive type declaration: AP 12.

reference type declaration: AP 3, 28. TAP 3, 4. Method args on AP 9, 18; TAP 2.

4. **Turing Machine.** Use this Turing Machine to answer the following questions. You may assume that the tape is initially filled entirely with # symbols except for the a's. Remember that the very first thing the Turing Machine does is read the symbol under the head.



#	#	#	#	a	a	a	a	a	#	#	#	#	#
#	#	#	#	X	a	a	a	a	#	#	#	#	#

Not all steps are shown:

#	#	#	1	X	a	a	a	a	#	#	#	#	#
#	#	1	0	X	X	a	a	a	#	#	#	#	#
#	#	1	1	X	X	X	a	a	#	#	#	#	#
#	1	0	0	X	X	X	X	a	#	#	#	#	#
#	1	0	1	X	X	X	X	X	#	#	#	#	#
#	1	0	1	X	X	X	X	X	#	#	#	#	#
#	1	0	1	#	#	#	#	#	#	#	#	#	#

#	1	0	1	#	#	#	#	#	#	#	#	#	#

(A.) For the starting tape shown on the first line of the table, with the head (at the shaded box and underlined) starting on the left-most a , what is the ending tape and the location of the head? Use the boxes provided and indicate the location of the head.

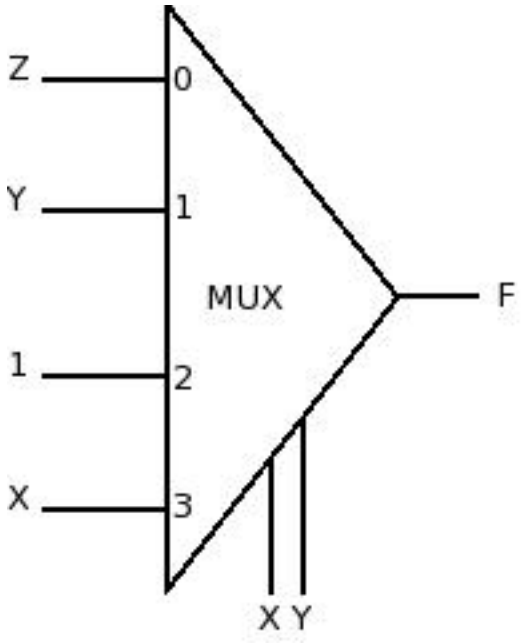
We have completed the first step for you as an example, with the result shown on the second line.

(B.) What function is this TM performing?

Unary-to-binary conversion; that is, the final tape contains the binary number representing the number of a's on the starting tape.

5. **Circuits.**

(A.) Using the table on the right, write the truth table for this multiplexer circuit. In the circuit `Y` is the low-order, or least significant bit, of the select input.



X	Y	Z	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

(B.) Write the Boolean algebraic expression for the circuit in simplest form. For partial credit, show the sum of products form.

F is false if and only if all of its inputs are false. This is the truth table for `OR`. The simplest-form answer is:

`X + Y + Z`

The sum of products is:

`X'Y'Z + X'YZ' + X'YZ + XY'Z' + XY'Z + XYZ' + XYZ`

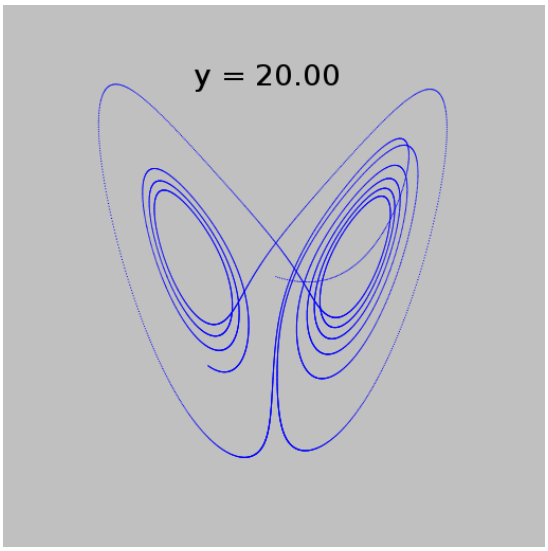
which can be reduced using Boolean algebra associativity, absorption, and complements.

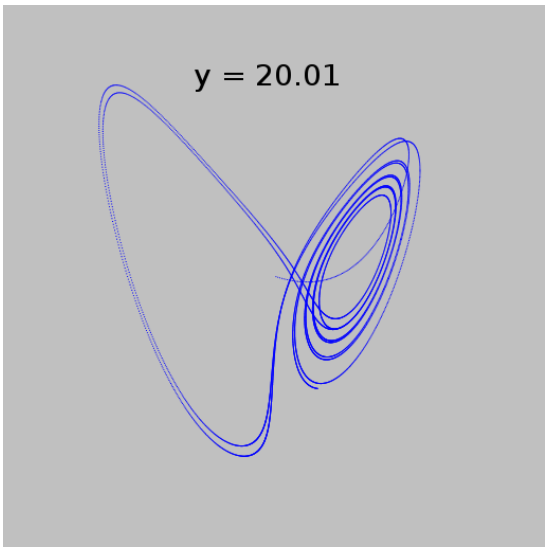
6. **Scientific Computation.**

The Lorenz Attractor is described by the following system of differential equations:

$$\begin{aligned}\frac{dx}{dt} &= -10(x+y)\\ \frac{dy}{dt} &= -xz + 28x - y\\ \frac{dz}{dt} &= xy - \frac{8}{3}z\end{aligned}$$

The two pictures below were generated by plotting the Lorenz Attractor in Java starting at $x = 0.0$, $z = 25.0$, and y as specified in the images. The same number of iterations were plotted for each image.





Which of the following best explains why the plots are so much different? Circle the best answer.

(i) Java is not using enough sample points and/or the samples are not taken uniformly.

(ii) Java uses the IEEE floating-point standard, so the Lorenz Attractor equations are unstable because of catastrophic cancellation.

(iii) The Lorenz Attractor equations are ill-conditioned, so minor changes to their initial conditions result in significant differences in behavior, regardless of the means used to calculate them.

7. **BST.** Suppose we have int values between 1 and 1000 in a Binary Search Tree and we search for 527. Mark as Y any of the following that could be the sequence of keys examined in a search for 527. Mark as N any sequence that could not result.

__Y__ (A.) 527
YES. We found 527 at the root.

__N__ (B.) 1 500 600 700 527
NO. 527 should be in 600's left subtree. 700 should be in 600's right subtree.

__N__ (C.) 605 256 490 300 527
NO. 527 should be in 490's right subtree. 300 should be in 490's left subree.

__Y__ (D.) 10 860 523 602 525 527
YES.

__N__ (E.) 10 860 523 602 599 610 527
NO. 610 should be in 602's right subtree, but we found it after going left from 602 to 599.

8. **Universality, Computability, and Intractability.** For each statement, identify if it is TRUE (`T`), FALSE (`F`), or UNKNOWN (`U`) in the space provided to the left of the statement.

__F__ (A.) If some Turing Machine (TM) matches a certain set of strings, then there is a corresponding Deterministic Finite-State Automaton (DFA) that matches the same set. FALSE.

__F__ (B.) P is the set of problems solvable in Polynomial time on a non-deterministic TM. FALSE. This is the definition we use for NP.

__F__ (C.) NP is the set of problems solvable in Non-Polynomial time on a non-deterministic TM. FALSE.

__U__ (D.) P equals NP. UNKNOWN.

__F__ (E.) Most computer scientists believe that the Halting Problem will eventually be proved decidable. FALSE. The Halting Problem has been proved undecidable.

__F__ (F.) If a polynomial time algorithm for SAT is found, then the Halting Problem is decidable. FALSE. The Halting Problem has been proved undecidable.

__U__ (G.) FACTOR (integer factorization) is NP-complete. UNKNOWN. FACTOR is known to be in NP and thus would be NP-Complete if P equals NP, but is not now known to be in P nor known to be NP-Complete.

__T__ (H.) Any problem solvable in polynomial time on your laptop can also be solved in polynomial time on a deterministic TM. TRUE

__T__ (I.) If the TSP problem is proved to be in P, then so is every other problem in NP. TRUE, because the TSP as used for our purposes is NP-Complete

__F__ (J.) If the TSP problem is proved NOT to be in P, then neither is any other problem in NP. FALSE. The problems already known to be in P (e.g. sorting) would still be in P even if P does not equal NP