NAME: **login id:**

                                                        Precept:

This test has 10 questions, weighted as indicated. The exam is closed book, except that you are allowed to use a one page cheatsheet (double-sided). No calculators or other electronic devices are permitted. Give your answers and show your work in the space provided.

Print your name, login ID, and precept number on this page (now), and write out and sign the Honor Code pledge before turning in this paper. *Note*: It is a violation of the Honor Code to discuss this midterm exam question with anyone until after everyone in the class has taken the exam. You have 50 minutes to complete the test.

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

_____

Signature

1	/3
2	/8
3	/5
4	/9
5	/5
6	/5
7	/8
8	/8
9	/11
10	/8
	/70

1. **Number Systems (3 points).** The following hexadecimal numbers represent 16-bit 2's complement numbers. Put them in order from lowest (most negative) to highest (most positive).

    0FFF   F000   1ABC   8888   FFFF

lowest _____

_____

_____

_____

highest _____

2. Combinational Circuits (8 points).

A. Complete the following truth table:

x	y	x AND y	x XOR y	x OR y
0	0			
0	1			
1	0			
1	1			

B. Mark T if the given Boolean expression is equivalent to (x OR y). Otherwise, mark F.

_____ (x AND y) OR (x OR y)

_____ (x OR y) AND (x AND y)

_____ (x AND y) OR (x AND y)

_____ (x OR y) OR x

C. Circle the one circuit below that computes (x OR y).
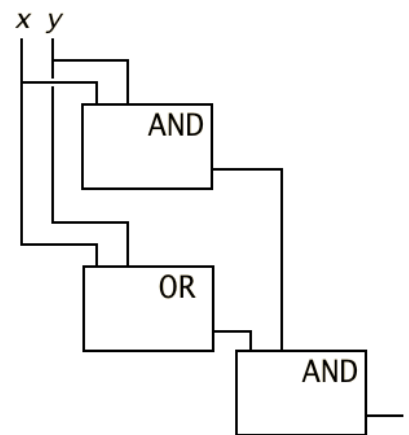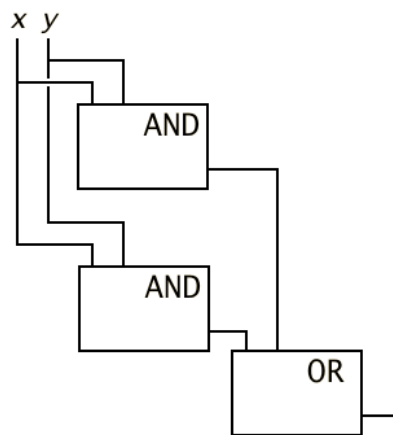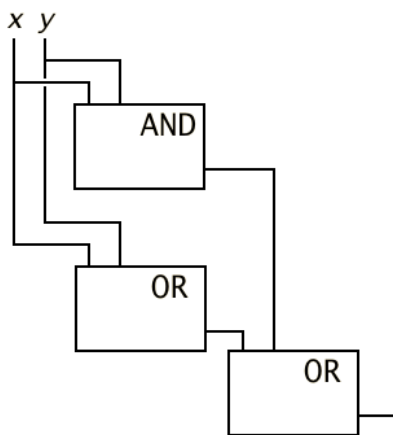
3. Programming languages (5 points). Consider the following five sentences.

1. We program a card game in C++ by first building a `Card` object, a `Deck` object and a `Player` object.

2. We declare instance variables to be `final` in Java.

3. We declare instance variables to be `private` in Java.

4. We use a function as an argument to another function in Python.

5. `public class ST<Key extends Comparable <Key>, Value>` implies that whatever data type we select as a `Key` will have a `compareTo()` method.

By writing a number in the blank to the left of each phrase (below), match each of the above sentences with the programming language capability with which it is best associated. Use each number once and only once.

_____ **A.** Immutability.

_____ **B.** Functional programming.

_____ **C.** Interface inheritance.

_____ **D.** Data abstraction.

_____ **E.** Encapsulation.

4. Regular languages (9 points). Consider the set of binary strings with no repeating consecutive digits: the set consisting of the empty string, `0`, `1`, `01`, `10`, `010`, `101`, `0101`, `1010`, etc.

A. For each of the REs below, write YES in the blank at left if the regular expression describes all strings in this set and only strings in this set. Otherwise, write NO.

_____   `(10)* | (01)*`

_____   `1 | 0 | (01)+ | (10)+`

_____   `(01)* | (10)* | 0(10)* | 1(01)*`

_____   `(1 | 0)* (0 | 1)*`

_____   `(1 | 0) | (01 | 10) | (01)* | (10)+`

B. The DFA at left below accepts the strings in the set of binary strings with no repeating consecutive digits (and only those strings) but is missing four arc labels. Provide the labels (`0` or `1`) for each of the arcs A, B, C, and D. Write your answers in the blanks to the left of the corresponding letters.
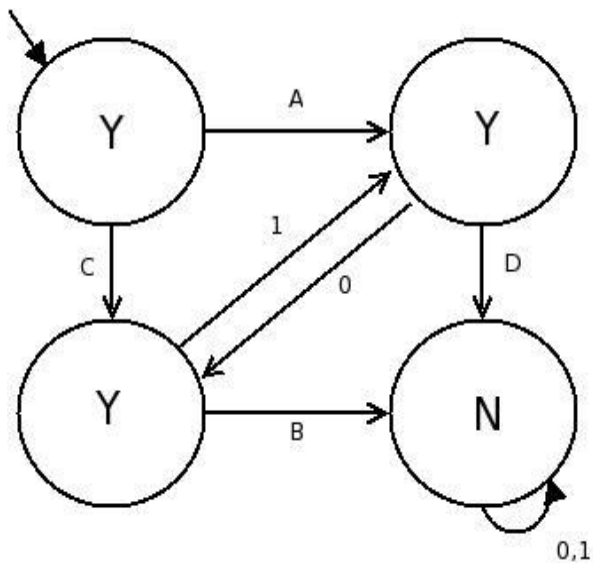
_____ A.

_____ B.

_____ C.

_____ D.

5. BSTs (5 points). Suppose that we create a BST by inserting the letters A through G into an initially empty tree. In the blank to the left of each of the following insertion orders write the height of the tree produced when keys are inserted in that order into an initially empty tree. Height is defined as the max distance from the root to any node. (e.g., A tree that has only its root and one child has height 2.) The first answer is provided for you.

A. __7__ A, B, C, D, E, F, G

B. __6__ B, A, C, D, G, F, E

C. __4__ D, C, E, B, A, F, G

D. __3__ D, B, F, A, C, E, G

E. __5__ E, D, C, A, B, G, F

F. __5__ C, B, D, A, E, G, F

6. Stacks and Queues (5 points). Consider the following Java program.

```java
public class Question6
{
   public static void main(String[] args)
   {
      Stack<String> s = new Stack<String>();
      Queue<String> q = new Queue<String>();
      while (!StdIn.isEmpty())
        s.push(StdIn.readString());
      for (String str : s)
        q.enqueue(str);
      for (String str : q)
        s.push(str);
      while (!s.isEmpty())
        StdOut.print(s.pop() + " ");
   }
}
```

Which of the following is the result of running this program with

```
mary had a little lamb
```

on standard input? Assume that the stack iterator uses LIFO order and the queue iterator uses
FIFO order. Circle your answer.

A.   lamb little a had mary

B.   mary had a little lamb mary had a little lamb

C.   mary had a little lamb lamb little a had mary

D.   lamb little a had mary lamb little a had mary

E.   mary had a little lamb

7. TOY (8 points). Consider what happens when the following TOY program is executed by pressing RUN with the program counter set to `10`:

```
10: 8110    R[1] <- Mem[10]
11: 7203    R[2] <- 03
12: 1212    R[2] <- R[1] + R[2]
13: 9214    Mem[14] <- R[2]
14: 0000    Halt
15: 0000    Halt
```

A. What is the value of `R[1]` after the instruction at location `10` completes?

B. What is the value of `R[2]` after the instruction at location `12` completes?

C. What is the value of `Mem[14]` after the instruction at location `13` completes?

D. What is the value of `R[1]` when the program halts?

8. Name game (8 points). Match the following names with an associated phrase. Use each letter once and only once.

A. Steve Cook   _____   Incompleteness

B. Alan Turing   _____   Reductions

C. Kurt Gödel   _____   Computability

D. James Gosling   _____   MS Word

E. Richard Karp   _____   NP-completeness

F. Alan Kay   _____   C++

G. Charles Simonyi   _____   Java

H. Bjarne Stroustroup   _____   Dynabook

9. Theory (11 points). In the blanks mark each of the statements below as true (T) or false (F).

A. _____ No RE matches a string shorter than itself.

B. _____ Any RE without closure (* or +) describes only finitely many strings.

C. _____ No problem in NP can be solved in polynomial time.

D. _____ It is possible to write a program that goes into an infinite loop if a given Java program goes into an infinite loop and terminates otherwise.

E. _____ If P equals NP, every problem in NP is NP-complete.

F. _____ No Turing machine can decide whether a given DFA halts on an arbitrary finite input.

G. _____ The Church-Turing thesis cannot be proven mathematically.

H. _____ If P equals NP, then the Traveling Salesperson Problem can be solved in polynomial time by a deterministic Turing Machine.

I. _____ If P does not equal NP, then the Traveling Salesperson Problem is not in P.

J. _____ Factoring is known to be in NP but has not been proven to be NP-complete.

K. _____ The discovery of a polynomial-time algorithm for TSP would not imply a polynomial-time algorithm for factoring.

10. Circuits (8 points). Match each term on the left with a phrase on the right by writing a letter in each blank space. Use each letter once and only once.

A. SR flip-flop   _____   holds instruction address during execution

B. multiplexor   _____   performs arithmetic operations

C. memory bit   _____   two cross-coupled NOR gates

D. decoder   _____   holds instruction during execution

E. control   _____   selects among multiple inputs

F. instruction register   _____   combinational circuit for sequencing

G. ALU   _____   sets addressed output to 1; others to 0

H. PC   _____   flip-flop with write timing control
                                                          and read selection mechanism