Name: _____ **Login id:**_____

Precept:_____

COS 126 Midterm 2 Written Exam Fall 2013

This test has 10 questions, weighted as indicated. The exam is closed book, except that you are allowed to use a one page cheatsheet (front and back). 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	/5
2	/7
3	/6
4	/6
5	/10
6	/6
7	/8
8	/12
9	/5
10	/5
	/70

1. Boolean Algebra and Combinational Circuits (5 points).

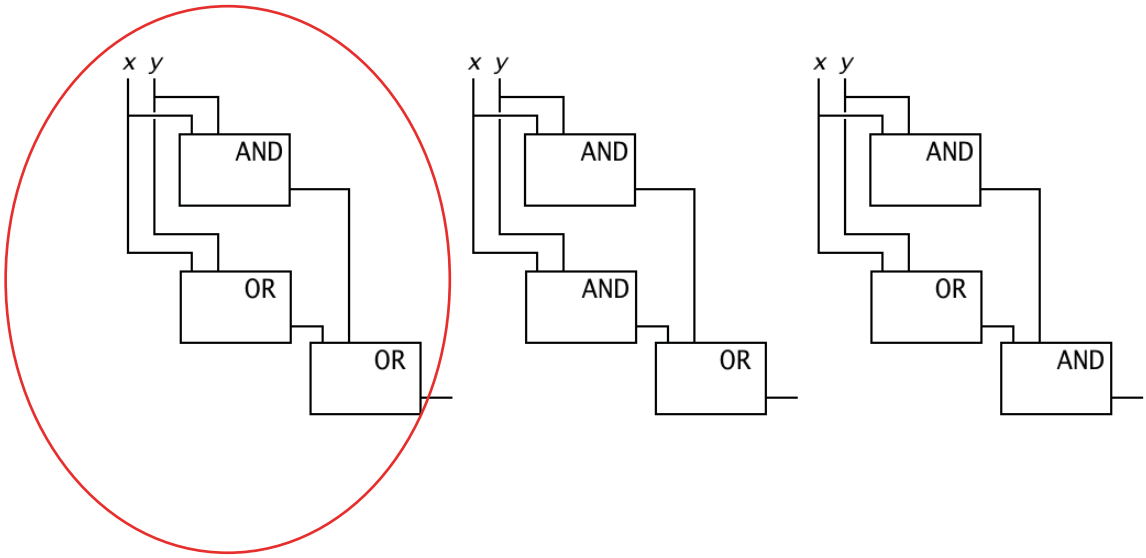
A. (3 points) In the blank at left of each of the boolean expressions below, mark T if the expression is equivalent to $x+y$. Otherwise, mark F.

T $xy + (x+y)$

F $xy\ (x+y)$

T $xy + (x'y')'$

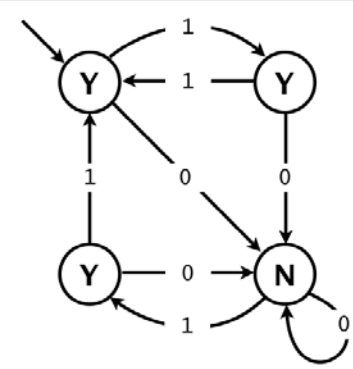
B. (2 points) Circle the one circuit below that computes $x+y$.



2. Programming languages (7 points). Write *YES* or *NO* in each of the seven unshaded boxes below to indicate whether or not the indicated programming language has the indicated property.

	can pass a function as an argument to another function	must declare types of variables	automatic garbage collection
C		YES	NO
Java	NO	YES	YES
Python	YES	NO	

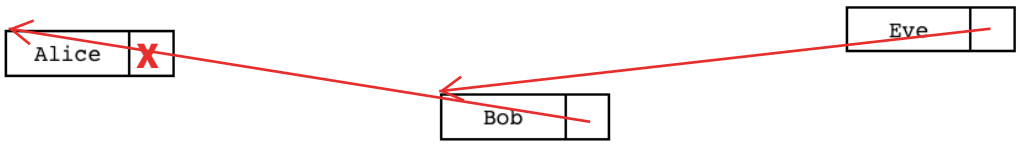
3. REs/DFAs (6 points). By circling *exactly one entry in each cell* in the table below, indicate which of the strings at the top are in the language described by the RE/DFA at the left.

	`010101`	`111110`	`000000`
`(0 | 11)*`	match **mismatch**	match **mismatch**	**match** mismatch
	**accept** reject	accept **reject**	accept **reject**

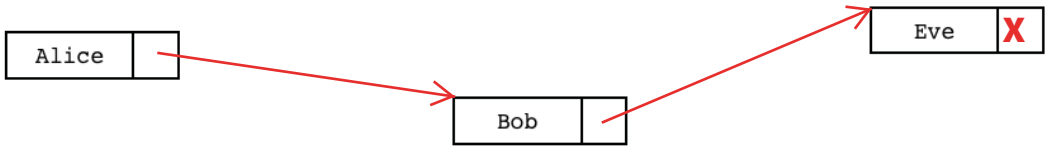
4. Linked structures (6 points). Examine the following code and answer the questions below:

```
public class Node
{
   private String name;
   private Node next;

   public Node (String s, Node n)
   {  name = s; next = n;  }

   public static void main(String[] args)
   {
      Node a = new Node("Alice", null);
      Node b = new Node("Bob", a);
      Node e = new Node("Eve", b);

      Node cur = e;
      Node temp = null;

      while (cur != null)
      {
         Node next = cur.next;
         cur.next = temp;
         temp = cur;
         cur = next;
      }
   }
}
```

A. (3 points) In the diagram below, draw arrows to indicate the node references after the first three statements (which create the nodes) in `main()` have been executed. If a node reference is `null`, mark the box with an X.



B. (3 points) In the diagram below, draw arrows to indicate the node references after the `while` loop in `main()` completes execution.



5. Creating Data Types (10 points).

Recall the `Point` data type from the TSP assignment. Your task for this question is to develop an API for a `LineSegment` abstract data type by filling in the blanks below the given instance method descriptions with full method *signatures* (the constructor signature is provided for you). For each method you must provide an access modifier, a return type, and parameter types and names when warranted, ***but not the code that implements the method***. We have provided the method names; your job is to fill in the blanks around them. Use the `Point` data type when it is logical to do so. For reference, *a line segment is a part of a line that is bounded by two distinct end points, and contains every point on the line between its end points.*

A. Constructor: create a line segment with two given end points.

```
public LineSegment(Point x, Point y)
```

B. Return the string representation of this line segment.

```
public String toString ()
```

C. Return `true` if the given point is contained by this line segment; `false` otherwise.

```
public boolean contains (Point p)
```

D. Return the slope of this line segment.

```
public double slope ()
```

E. Return *N* equally-spaced points that are contained by this line segment.

```
public Point[] sample (int N)
(or Queue<Point>, etc)
```

F. Return the point at the intersection of this line segment and the given line segment (*null* if none exists).

```
public Point intersection (LineSegment other)
```

6. BSTs (6 points). In the blanks provided write *yes* next to any of the following sequences that could be the sequence of keys examined in a search for the letter **M** in some binary search tree containing the letters of the alphabet. Write *no* next to any sequence that could not result from such a search.

A. yes A B C Z L M.

B. no C U F N P K M.

C. no G Q H I K R M.

D. yes Z C Y F K P M.

E. no E U G P K H M.

7. Computability/Intractability (8 points). For each of the computational problems below, indicate its difficulty by writing the most appropriate choice of *X* (not computable), *NPC* (NP-complete), *P* (tractable), or *DFA* (solvable by a DFA) in the blank at left.

A. X Checking whether any given program contains a virus.

B. P Compiling any given Java program.

C. NPC Determining whether there exists a set of inputs for which any given combinational circuit computes 1.

D. DFA Checking whether any given string is a valid e-mail address.

E. DFA Checking whether any given DNA sequence contains ACGGAC.

F. NPC Finding an optimal traveling salesperson tour through any given set of points.

G. X Solving Post's correspondence problem.

H. P Checking whether any given string has an equal number of 0s and 1s.

8. TOY/Turing (12 points). Consider the following ten simple operations that might be performed on a 16-bit 2s complement binary integer (ignore overflow).

0. No-op (no change).

1. Flip all bits (0s to 1s and 1s to 0s).

2. Multiply by 2.

3. Multiply by 4.

4. AND with 1.

5. Add 1.

6. Subtract 1.

7. Shift left 2.

8. XOR with all 1s.

9. Negate (multiply by -1).

A. (6 points) Indicate which of the operations is performed on the contents of R7 by each of the three TOY code sequences below by writing a number between **0** and **9** in the box to the left of each. Assume the TOY sequences are independent; they do not come after one another.

9

```
7101    R1 <- 0001
2201
4772
1771    R7 <- R7 + R1
```

0

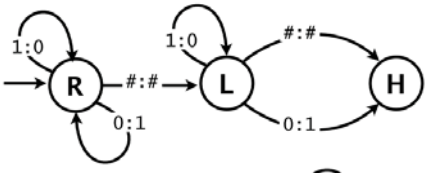
```
4779    R7 <- R7 ^ R9
4779    R7 <- R7 ^ R9
```

2

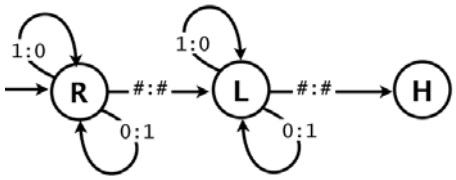
```
7101    R1 <- 0001
5771
```

B. (6 points) Indicate which of the operations is performed by each of the Turing machines below by writing a number between **0** and **9** in the box to the left of each. As usual, we omit transitions to the same state that do not change the symbol. The input is a (2s complement) binary number on the tape (surrounded by #s). The head starts on the left bit. The output is the (2s complement) binary value of the final tape contents.

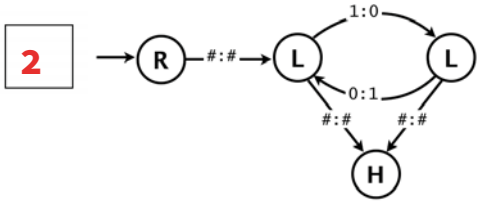
9



0



2



TOY REFERENCE CARD

INSTRUCTION FORMATS

```
             | . . . . | . . . . | . . . . | . . . .|
  Format 1:  | opcode  |    d    |    s    |    t    |  (0-6, A-B)
  Format 2:  | opcode  |    d    |       addr        |  (7-9, C-F)
```

ARITHMETIC and LOGICAL operations

```
    1: add              R[d] <- R[s] +  R[t]
    2: subtract         R[d] <- R[s] -  R[t]
    3: and              R[d] <- R[s] &  R[t]
    4: xor              R[d] <- R[s] ^  R[t]
    5: shift left       R[d] <- R[s] << R[t]
    6: shift right      R[d] <- R[s] >> R[t]
```

TRANSFER between registers and memory

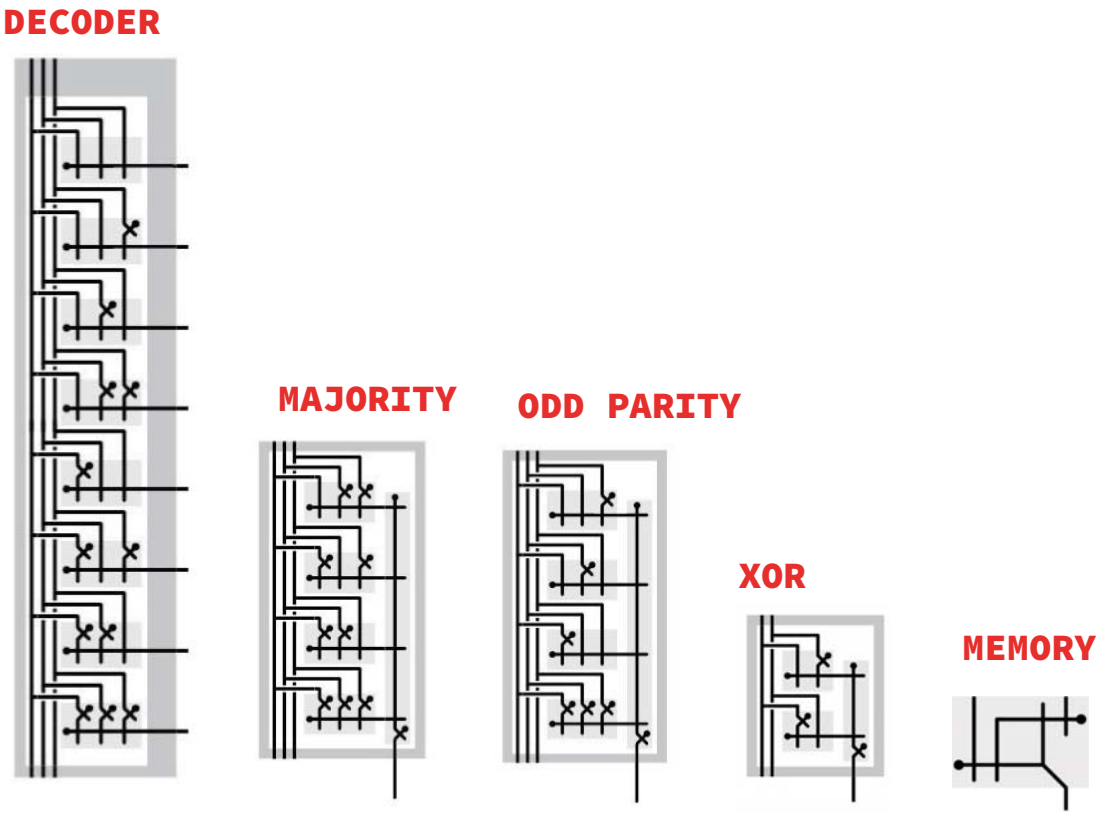
```
    7: load address     R[d] <- addr
    8: load             R[d] <- mem[addr]
    9: store            mem[addr] <- R[d]
    A: load indirect    R[d] <- mem[R[t]]
    B: store indirect   mem[R[t]] <- R[d]
```

CONTROL

```
    0: halt             halt
    C: branch zero      if (R[d] == 0) pc <- addr
    D: branch positive  if (R[d] >  0) pc <- addr
    E: jump register    pc <- R[d]
    F: jump and link    R[d] <- pc; pc <- addr
```

Register 0 always reads 0.
Loads from mem[FF] come from stdin.
Stores to mem[FF] go to stdout.

9. Circuits (5 points). Identify the circuits below by writing one of the identifiers *DECODER*, *MAJORITY*, *MEMORY BIT*, *ODD PARITY* or *XOR* *above* each of them. (Inputs are at the top and outputs are on the right or at the bottom.)



10. CPU (5 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	E	holds instruction address during execution
B.	IR	D	performs arithmetic operations
C.	bus	C	set of parallel wires
D.	ALU	A	two cross-coupled NOR gates
E.	PC	B	holds instruction during execution