COS 126 General Computer Science Spring 2013

Written Exam 2

This test has 9 questions, weighted as indicated. The exam is closed book, except that you are allowed to use a double-sided cheatsheet. 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. It is a violation of the Honor Code to discuss this exam until everyone in the class has taken the exam. You have 50 minutes to complete the test.

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."

Pledge: ______________________________

____

Signature: ______________________

Problem	Score
0	/1
1	/9
2	/8
3	/9
4	/9
5	/10
6	/9
7	/7
8	/8
Total	/70

Name: ______________________

NetID: ______________________

Precept: ______________________

P01	12:30 TTh	Dave Pritchard
P01A	12:30 TTh	Donna Gabai
P01B	12:30 TTh	Pawel Przytycki
P02	1:30 TTh	Tom Funkhouser
P02A	1:30 TTh	Allison Chaney
P02B	1:30 TTh	Pawel Przytycki
P02C	1:30 TTh	Vivek Pai
P02D	1:30 TTh	Siddhartha Chaudhuri
P03	2:30 TTh	Tom Funkhouser
P03A	2:30 TTh	Allison Chaney
P04	3:30 TTh	Vivek Pai
P04B	3:30 TTh	Shilpa Nadimpalli
P05	7:30 TTh	Shilpa Nadimpalli
P06	10am WF	Lennart Beringer
P07	1:30 WF	Dave Pritchard
P07A	1:30 WF	Kevin Lee
P07B	1:30 WF	Siyu Liu
P08	12:30 WF	Donna Gabai
P08A	12:30 WF	Judi Israel
P09	11am WF	Judi Israel

0. **Very Short Question** (1 Point)

   You will get one point if you are taking this midterm in the correct room at the correct time.

1. **Short Questions** (9 Points)

   (a) Can the fraction $\frac{3}{2}$ be *exactly* represented as a `double` in Java?

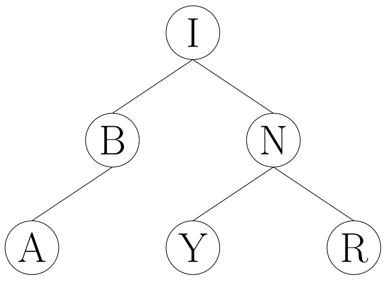
   Circle one: YES NO

   (b) Can the fraction $\frac{1}{10}$ be *exactly* represented as a `double` in Java?

   Circle one: YES NO

   (c) This diagram illustrates an improperly built binary search tree. On the line below, write a letter that is in the tree, but which will not be found when you search for it using binary search.

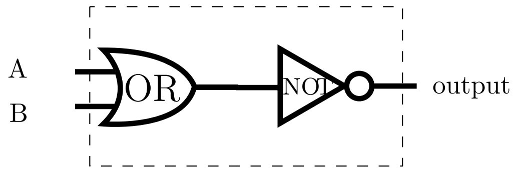
   The letter that cannot be found by binary search is: ________



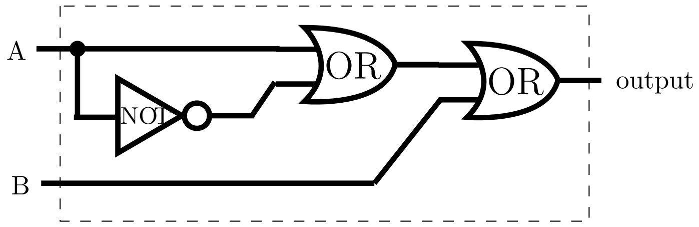
   (d) Draw the binary search tree that results when, starting with an empty tree, you insert T, I, G, E, R in that order. (Showing the intermediate steps separately is not mandatory. If you draw multiple trees, you must circle your final answer.)

2. **Circuits** (8 Points)

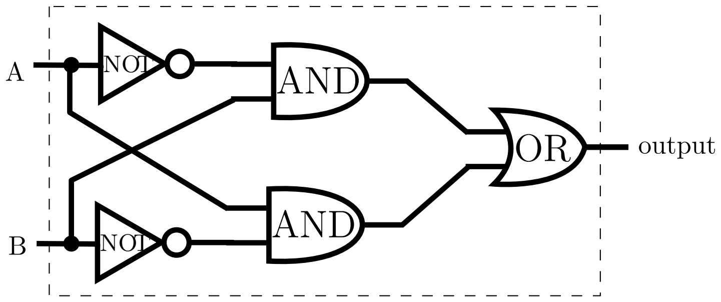
There are four circuits below, each of which takes two inputs A, B and produces a single output. On the blank under each circuit, determine which of the six descriptions (1 through 6) describes it, and write that *number* in the blank. *Some of the numbers may be used* ***more than once****, or zero times.*



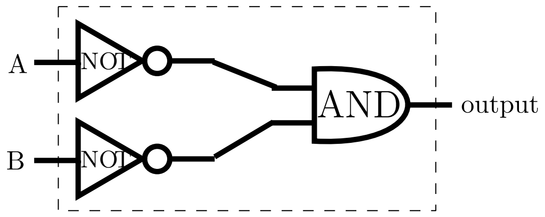
This circuit's output is: ______



This circuit's output is: ______



This circuit's output is: ______



This circuit's output is: ______

1: always true

2: always false

3: true if and only if A and B are equal

4: true if and only if A and B are both false

5: true if and only if A and B are not equal

6: true if and only if A and B are both true

You must choose from these descriptions; do not write a boolean formula on the answer line.

3. **Java and Object-Oriented Programming** (9 Points)

   Match the following Java keywords to the most appropriate description. Write *one* letter in each blank, referring to the descriptions below. *Each letter will be used exactly once.*

   - `class`: ________
   - `public`: ________
   - `static`: ________
   - `void`: ________
   - `main`: ________
   - `private`: ________
   - `this`: ________
   - `null`: ________
   - `new`: ________

   A: defines something as being part of the API

   B: creates an instance

   C: the value for reference-type variables when they do not refer to an instance

   D: hidden from clients in other `.java` files

   E: method name that is called when `java` is run from the command line

   F: return type of a method that does not return any value

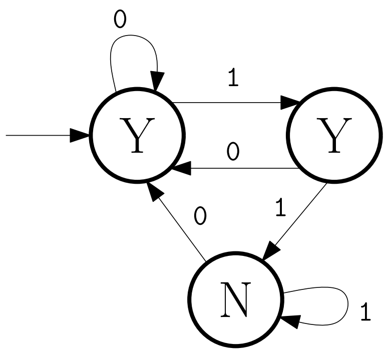
   G: belongs to a class rather than to instances of that class

   H: contains definitions of methods and fields

   I: refers to the instance upon which the current method or constructor acts

4. **DFAs and REs** (9 Points)

   This table has a DFA or an RE in each row, and a 3-character string in each column. Determine whether each RE matches each string, and whether the DFA accepts each string. *Circle the correct choice in each box.*

	010	110	011
`(0|1)*`	Matches Doesn't Match	Matches Doesn't Match	Matches Doesn't Match
	Accepts Rejects	Accepts Rejects	Accepts Rejects
`(0|01)*`	Matches Doesn't Match	Matches Doesn't Match	Matches Doesn't Match

5. **Theory** (10 Points) The year is 2020, and you are running the Google^{TM} software company. A team of your employees tells you they have written a great new Java program! For each description of the program, determine the appropriate reply or replies: write the letters of **all** appropriate replies in the corresponding blank.

   Fill each blank with ***one or more*** *letters. Some letters may be used* ***more than once*** *or zero times.*

   Your employees say their program:

   - can check whether any given string has an equal number of 0's and 1's.

     Appropriate reply/replies: __________

   - can factor, in polynomial time, any given positive integer into its prime factors.

     Appropriate reply/replies: __________

   - can determine, in polynomial time, whether any given boolean satisfiability formula has a solution.

     Appropriate reply/replies: __________

   - can simulate the execution of a TOY machine for any given initial values of its registers and memory.

     Appropriate reply/replies: __________

   - can take any `.java` file as input, and determine whether it would print the letter Q when run. (Assume the program in the `.java` file takes no inputs.)

     Appropriate reply/replies: __________

   Your possible responses (pick all that apply):

   A: "Are you sure? That means P=NP."

   B: "Wow! That disproves the Church-Turing thesis."

   C: "Can't be. That problem is undecidable."

   D: "That means RSA encryption can be broken with polynomial-time algorithms."

   E: "FedEx will be happy because now they can find optimal routes for their trucks in polynomial time."

   F: "No big deal. We could have done that in COS 126."

6. **Linked Structures** (9 Points) Consider the code listing below.

```
 1 public class Box {
 2    private int val;
 3    private Box a;
 4    private Box b;
 5
 6    public static void main(String[] args) {
 7        Box x = new Box();
 8        Box y = new Box();
 9
10        x.val = 0;
11        x.a = x;
12        x.b = y;
13
14        y.val = 1;
15        y.a = x;
16        y.b = null;
17
18        Box tmp = x;
19        x = y;
20        y = tmp;
21
22        y.b.a = x.a.b;
23    }
24 }
```

Suppose that we call the `main` method.

(a) After line 16 executes, what is the value of `x.b.val`? *Write the value here:* ________

(b) After line 20 executes, what is the value of `x.a`? *Check one of the 3 boxes below.*

☐ Refers to a `Box` with `val` 0 ☐ Refers to a `Box` with `val` 1 ☐ `null`

(c) After line 20 executes, what is the value of `x.b`? *Check one of the 3 boxes below.*

☐ Refers to a `Box` with `val` 0 ☐ Refers to a `Box` with `val` 1 ☐ `null`

(d) After line 20 executes, what is the value of `y.a`? *Check one of the 3 boxes below.*

☐ Refers to a `Box` with `val` 0 ☐ Refers to a `Box` with `val` 1 ☐ `null`

(e) After line 20 executes, what is the value of `y.b`? *Check one of the 3 boxes below.*

☐ Refers to a `Box` with `val` 0 ☐ Refers to a `Box` with `val` 1 ☐ `null`

(f) Which field changes when line 22 executes? *Check one of the 5 boxes below.*

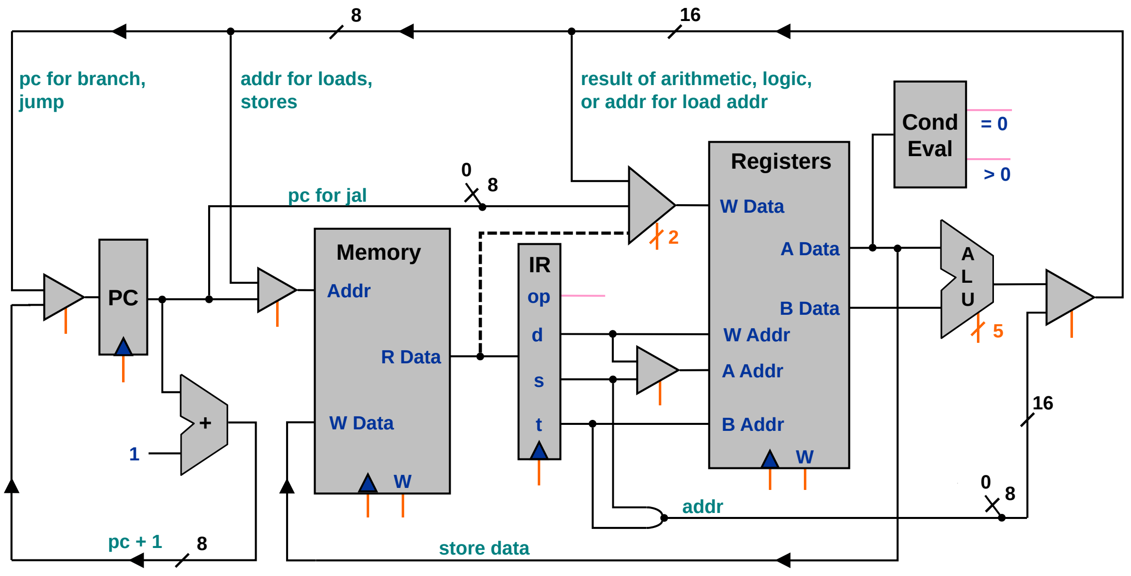
☐ `x.a` ☐ `x.b` ☐ `y.a` ☐ `y.b` ☐ n/a: a NullPointerException occurs

TOY Reference Card *You may use this for the next problem on the facing page.*

```
             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.
pc starts at 10

16-bit registers
16-bit memory locations
 8-bit program counter
```

7. **Architecture** (7 points)

The TOY architecture diagram is shown below, but one of the paths in the center is shown with a dashed line.



Suppose the dashed path were removed. For each of the opcodes below, would it still work even after the path was deleted? *Circle the correct answer on each line.* The **TOY reference card** is provided on the facing page.

and (opcode 3)	Would still work	Would no longer work
load address (opcode 7)	Would still work	Would no longer work
load (opcode 8)	Would still work	Would no longer work
store (opcode 9)	Would still work	Would no longer work
load indirect (opcode A)	Would still work	Would no longer work
store indirect (opcode B)	Would still work	Would no longer work
branch positive (opcode D)	Would still work	Would no longer work

8. **Turing Machines** (8 points)

Below is an incomplete diagram of a Turing Machine. Complete the diagram of the Turing Machine so that it satisfies the following specification:

- Assume the initial tape consists of a binary string surrounded by infinitely many # symbols on both sides.
- Assume the initial head location is the leftmost bit.
- Assume the initial state is the state labelled R on the left. (Recall that the Turing Machine's first step is reading/writing, not moving the head.)
- Let N be the length of the binary string on the input tape. Interpret the input as an N-bit two's-complement binary integer. After the Turing machine halts, the N-bit number that remains on the tape should be the **negative** of the original input. (Recall that computing the negative of a number involves flipping all of the bits and then adding one.)

Fill in exactly one symbol in each of the eight empty boxes below so as to satisfy this specification. *Do not add new states or new transitions, and do not use any tape symbols other than #, 0, 1.*