COS 116
The Computational Universe
Midterm Exam
March 13, 2008

This is a closed-book exam, but you may refer to the pseudocode handout from class. Do not discuss this exam with another student until Friday 5pm.

Princeton Honor Code: *Copy the pledge and sign your name below.*

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

Question	Points
1	/ 20
2	/ 7
3	/ 8
4	/ 12
5	/ 18
Total	/ 65

1. (20 points) Answer in one or two sentences.

a) (2 points) What is the halting problem?

b) (2 points) What is the Droste Effect?

c) (2 points) We saw that sound is a wave. What parameter of the wave determines its loudness?

d) (2 points) What is the decimal representation of `111010`?

e) (2 points) Suppose you play the game of "I have a number in mind in mind from 1 to a 1000. Guess it using yes/no questions." What is the minimum number of questions that suffice? Explain your answer.

f) (2 points) Suppose human ears could only detect sounds with frequencies from 40Hz to 5kHz. (They actually detect frequencies from 20Hz to 20KHz.) How would that change the sampling rate used for producing audio CDs and how would it change the amount of memory needed to store an audio CD?

g) (4 points) Name two methods used to synthesize the sound of an instrument (say, flute) on a computer. Describe each in a line or so.

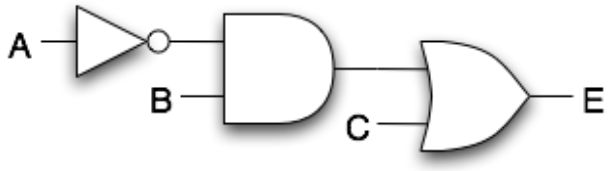
h) (4 points) What is a cellular automaton? Name 2 cellular automata discussed in the lectures.

2. (7 points) A Turing-Post Program

What does the following Turing Post program do? Add one line to it to turn it into a program that never halts on any input. (You cannot remove the "HALT" command at the end.)

```
1    PRINT 0
2    GO LEFT
3    GO RIGHT
4    PRINT 0
5    HALT
```

3. (8 points) Digital Logic



Given the Boolean circuit above,

(a) (2 points) Write a Boolean formula expressing E in terms of A, B, C.

(b) (6 points) Write the truth table for `E` in terms of `A`, `B`, `C`.

4. (12 points) Scribbler "Exercise"

Your Scribbler needs to get some exercise. So, you draw two black lines on the ground and place your robot facing the line on the right.

You want your robot to exercise back-and-forth between the two lines by moving forwards until it touches the right line, then moving backwards until it touches the left line, and so on. You load the following pseudocode onto your robot:

```
Do forever
{
   If Not <Line on Either Side>
   {
      Move Forward for 1 s
   }
   Move Back for 1s
   If Not <Line on Either Side>
   {
      Move Back for 1 s
   }
   Move Forward for 1 s
}
```

Does the Scribbler exhibit the desired behavior with the above pseudocode? (Assume the distance between the lines is much larger than the distance the Scribbler moves in 1 second, and the thickness of the line is less than the distance the Scribbler moves in 1 second.) If not, explain what the pseudocode does and how you would fix it to produce the desired behavior. (Hint: The fix is not complicated.)

5. (18 points) Pseudocode

In the following pseudocode:

```
d ← 2
Do for i = 1 to 3
{
     d ←  d × d
}
END
```

(a) Find the value of d after the i^{th} loop execution by filling the table below:

i	1	2	3
d			

(b) During the initialization of d, if we replace 2 by some input variable k, what is the value of d at the end of the program (in terms of k)? What is the running time of the program?

(c) In the "`Do for 3 times`" statement, if we replace `3` by some input variable n, what is the value of d at the end of the program? (Express it as a formula in n.) What is the running time of the program then?