Midterm Exam
COS 116 Spring 2012: The Computational Universe

Name: SOLUTION

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This is an in-class exam. No collaboration is allowed. There are 9 questions on 4 pages.
You may use the back sides of the pages if you run out of room on the front.

Write and sign the honor pledge:

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

1. Scribbler:
(a) Write the pseudocode for a program that will cause the Scribbler robot to (in theory) repeatedly drive over the sides of a square until its batteries run out.

```
Do forever
{
	Go forward for 1 sec
	Turn Right
}
```

(b) If you download that program to a Scribbler robot, will it actually do that? Explain briefly.

No. Calibration errors mean it won't turn exactly 90 degrees or go the same distance each time. Batteries wear out.

2. Binary:
(a) What is the binary representation of the decimal number 19? 10011

(b) What is the binary representation of the decimal number 4? 100

(c) Add these two numbers using binary arithmetic:

10011
<u>00100</u>
10111

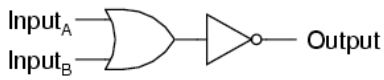
(d) How many different integers can be encoded in 16 bits?

2^{16}

3. Brooks:
According to Brooks, which is harder for a machine – playing chess or walking on two legs? Which problem is he more interested in and why?

Walking is harder for a machine and Brooks says this is the more interesting problem for him. (See reading pp36-37).

4. A circuit:



(a) Write an equivalent boolean expression, by writing a component (AND OR NOT, or the suitable math symbols) for each gate:

O = NOT (A OR B)

(b) Write the truth table for this circuit:

A	B	O
0	0	1
0	1	0
1	0	0
1	1	0

(c) Write an equivalent expression from the truth table: (NOT-A) AND (NOT-B)

(d) Show that the expressions in (a) and (c) are equivalent, using rules from boolean algebra.

DeMorgan's Law

5. Digital audio:

(a) What does 44khz mean?

44 thousand cycles per second

(b) Why do audio CDs sample at 44 khz?

We hear sounds up to about 20khz. The Nyquist law says we should sample at least twice this rate for accurate reproduction. And a little extra for good measure.

(c) Why do audio CDs use 16 bits per sample?

This allows us to have small quantization error (i.e. good fidelity) in the audio signal.

6. A Turing Post program:

1. GO RIGHT
2. GO TO STEP 1 if 1 SCANNED
3. STOP

(a) What does this program do?

This program looks to the right for the first 0.

(b) Could we use a Universal program to determine if this program would halt for arbitrary inputs?

No because if the tape is all 1's then the TP program will look to the right forever, and the Universal program would have to run forever to discover this. (That is, it will never say "no".)

7. Stable marriage:

Suppose three women, ABC, and three men, XYZ, have these preferences for marriage (left to right):

A: YXZ B: ZYX C: XZY X: BAC Y: CBA Z: ACB

Mark these matchings as either "stable" or "unstable" by circling the correct word:

(a) AY, BZ, CX   [stable]   unstable

(b) AX, BY, CZ   [stable]   unstable

(c) AZ, BX, CY   [stable]   unstable

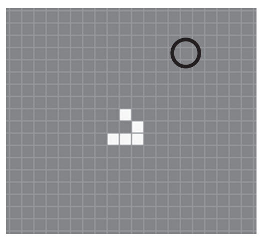
(d) What matching would be produced by the Gale-Shapley algorithm when men propose?

Same as (c).

8. Conway's game of life:

- *Survival:* Critter survives if it has: 2 or 3 neighbors.
- *Death:* Critter dies if it has: 1 or fewer neighbors, or more than 3.
- *Birth:* New critter is born if cell is currently empty and 3 neighboring cells have critters.

Here is a configuration at time 1:



(a) Ignore the circle for now. Draw the arrangement of live critters at times 2, 3 and 4:

time 2:   time 3:   time 4:

This is the glider – try it out here: http://www.bitstorm.org/gameoflife/

(b) Can we know if this configuration will ever place a critter in the circled cell? Briefly explain. (If yes: will it do so? Or if no: why not?)

Yes we can know. This particular configuration is a "glider" that forever travels down and to the right, cycling through 4 arrangements of critters. You can see by inspection it will *never* hit the circled cell, as it always continues down and to the right.

9. Search

Suppose the city phone directory is a long list of one million names with phone numbers, listed in alphabetical order by name.

(a) How might a computer look up a particular name to see if it is in the list?

Record the names in ASCII and compare names by comparing numbers. Use binary search to look for the name in the long list. (First compare against the 500,000th name; if earlier we know to search the first half; check the 250,000th name, etc.)

(b) How many entries would you expect it to have to check? $\log_2$ (1 million) = roughly 20.