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*COS 116: Spring 2007*  
*The Computational Universe*  
**Midterm**

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Please print this document and write your answers on it. This exam is 3 hours long and closed book and closed notes, except that you may refer to the pseudocode handout available from the course webpage. (You may wish to print it out too before you start the exam.) No collaboration is allowed. Please write and sign the honor pledge:

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

Your answers are due by Friday, March 16, 2007 at 3pm. You must give them to Donna O'Leary in Room 410 in the Computer Science building by that time. If she isn't there, please slide your exam under her door.

If you have any questions during the exam, you may contact the course staff at the usual [cos116@lists.cs.princeton.edu](mailto:cos116@lists.cs.princeton.edu) address.

This exam has 7 pages. Each problem is marked with a number of possible points, totaling 63.

page	points	possible
2		15
3		8
4		16
5		7
6		10
7		7
Total:		63

1) (8pts) Suppose  $i$  is a variable with the value 4 and  $j$  is a variable with the value 8.

(a) What are the values of  $i$  and  $j$  after executing the instruction  $i \leftarrow i/j$ ?

(b) How would you swap the values in  $i$  and  $j$ ?

(c) Roughly how many times could you swap these two variables before they wear out and break?

(d) On a modern conventional 900Mhz computer, roughly how many times could you swap these two variables in two seconds?

2) (4pts) Consider two sound files, A and B:

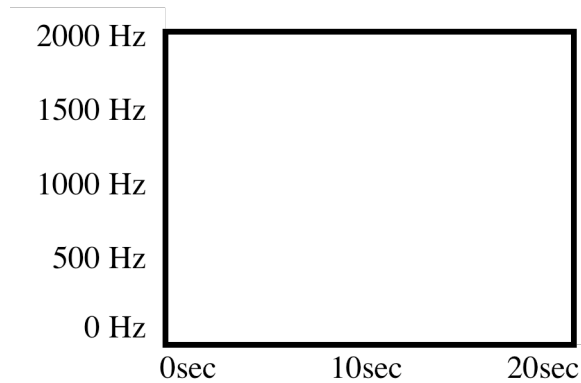
- File A contains frequencies in the range 1000 Hz – 3000 Hz, and
- File B contains frequencies in the range 2000 Hz – 5000 Hz.

Suppose you sample each file at 6000 Hz. Will the sampled versions of either file sound significantly distorted? Explain your answer (ignore quantization noise).

3) (3pts) If you give the Scribbler the following instruction:

“Move <Left Wheel Speed 50%, Right Wheel Speed 90%> for 1s”  
what basic action will it take? (A few words.)

- 4) (3pts) Consider a 10 second sound file that consists of 1000 Hz sine wave plus a 500 Hz sine wave. Plot this sound on the spectrogram below.



- 5) (3pts) Consider the following pseudocode:

```
 $f \leftarrow 1$   
for  $i = 1$  to  $n$   
{  
     $f \leftarrow f \times 2$   
}
```

After this algorithm completes, the value of  $f$  is equal to  $2^n$ .

The factorial function, denoted  $n!$ , is defined  $n! = n \times (n-1) \times (n-2) \times \dots \times 1$ . For example,  $3! = 3 \times 2 \times 1 = 6$ .

Change one line of the above program so that, when the program completes, the value of  $f$  is equal to  $n!$ .

- 6) (2pts) In what year was the first female ever awarded the Turing Award?

7) (7pts) Consider the following pseudocode:

```
 $f \leftarrow 0$   
while ( $n > 1$ )  
{  
     $n \leftarrow n / 2$   
     $f \leftarrow f + 1$   
}
```

- (a) What is the value of  $f$  at the end of the program if the initial value of  $n$  is 8?
- (b) What is the value of  $f$  at the end of the program if the initial value of  $n$  is 10?
- (c) In general, what is the value of  $f$  at the end of the program?  
Express your answer as a function of  $n$ .
- 8) (4pts) In computer graphics rendering processes, what is the primary difference between how the *direct* and *global* illumination models work? (1-2 sentences.)
- 9) (5pts) What does a web crawler do and how does it do it? (1-3 sentences.)

10) (7pts) Gale-Shapley Algorithm for the Stable Marriage Problem (men propose):

```
Initialize each person to be free.
while (some man  $m$  is free and hasn't proposed to every woman)
{
     $w$  = first woman on  $m$ 's list to whom he has not yet proposed
    if ( $w$  is free)
        { assign  $m$  and  $w$  to be engaged }
    else if ( $w$  prefers  $m$  to her fiancé  $f$ )
        { assign  $m$  and  $w$  to be engaged, and  $f$  to be free }
    else
        {  $w$  rejects  $m$  }
}
```

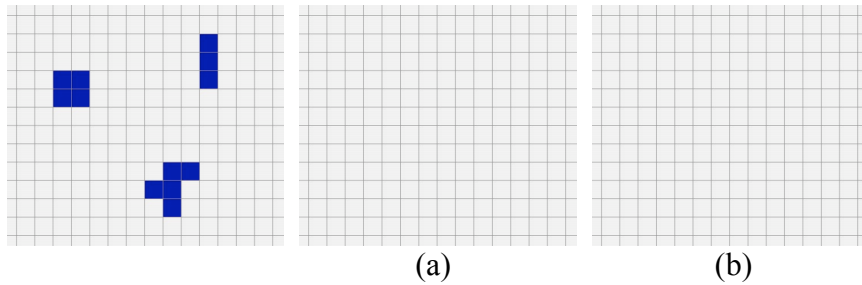
Please write the whole word, *TRUE* or *FALSE*:

- (a) Given partner preference lists for 5 men and 5 women, this algorithm will find a stable matching for every man and every woman.
- (b) Given partner preference lists for 31 men and 31 women, this algorithm will find a stable matching for every man and every woman.
- (c) Suppose that there is a set of partner preference lists (input) that could lead to two different possible stable matchings. If you run this algorithm ten different times with this input, sometimes you will get one stable matching and sometimes you will get the other.
- (d) There are some very tricky partner preference lists (input) that could cause this algorithm to loop forever.
- (e) In this algorithm, once a man is engaged, he will never be single again.
- (f) In this algorithm, once a woman is engaged, she will never be single again.
- (g) If you switch the algorithm so that the women propose instead of the men, the women will generally do better (and the men worse) than they do in the formulation above.

11) (10pts) Remember the rules of Conway's Game of Life:

- A critter may have up to 8 neighbors in the surrounding cells.
- A critter survives if it has 2 or 3 neighbors.
- A critter dies if it has 0, 1 or more than 3 neighbors.
- A critter is born in an empty cell if there are 3 neighbors.

(a) and (b) Starting with the configuration shown on the left, fill in the next two time steps to its right.



(c) Suppose that no critters ever reach the cells *surrounding* the square of four critters near the upper left corner. Will those four critters ever die? Why? (1-2 sentences.)

(d) Is this supposition reasonable? Could we write a computer program that would tell us for sure whether or not one of those surrounding cells would ever be occupied? (1-2 sentences.)

(e) In what sense are snowflakes like the critter formations above? (1-2 sentences.)

12) (3pts) What is the “halting problem”? (1-2 sentences.)

13) (4pts) What would it mean for a program to take itself as input? (1-2 sentences.)